Report of the Chief

of the

Bureau of Agricultural Chemistry

and

Engineering

1941

REPORT OF THE CHIEF OF THE BUREAU OF AGRICULTURAL CHEMISTRY AND ENGINEERING, 1941

United States Department of Agriculture,
Bureau of Agricultural Chemistry and Engineering,
Washington, D. C., October 15, 1941.

Hon. Claude R. Wickard,
Secretary of Agriculture.

Dear Mr. Secretary: I present herewith the report of the Bureau of Agricultural Chemistry and Engineering for the fiscal year ended June 30, 1941.

Sincerely yours,

Henry G. Knight, *Chief.*

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INTRODUCTION

The Bureau of Agricultural Chemistry and Engineering was established October 16, 1938, by order of the Secretary of Agriculture. Its functions are to coordinate and continue the scientific and technological research on agricultural products, formerly carried on

in the Bureau of Chemistry and Soils, and the agricultural engineering research, excepting that on irrigation and drainage, formerly carried on in the Bureau of Agricultural Engineering. At the time of its establishment this Bureau was directed to administer and operate the four Regional Research Laboratories authorized by the Agricultural Adjustment Act of 1938 for the purpose of conducting research into, and developing new scientific, chemical, and technical uses and new and extended markets and outlets for farm commodities and their products and byproducts. This Bureau also participates in the Department's program of basic research in agriculture under the Bankhead-Jones Act of June 29, 1935. Most of these special research projects are carried on by regular units of the Bureau because they are closely related to the work of those units. However, special units were established for research on soybeans and soybean products and on the allergens of agricultural products.

The present organization of the Bureau of Agricultural Chemistry and Engineering is as follows: Chief; Associate Chief; three Assistant Chiefs; Division of Administrative Services; Division of Personnel; Division of Information; Library; United States Agricultural Byproducts Laboratory; United States Regional Soybean Industrial Products Laboratory; Division of Agricultural Chemical Research; Division of Chemical Investigations of Allergens in Agricultural Products; Enzyme Research Laboratory; Division of Farm Mechanical Equipment Research; Division of Farm Structures Research; Division of Mechanical Processing of Farm Products; Division of Naval Stores Research; Division of Plans and Service; Division of Protein and Nutrition Research; Division of Rural Electrification Research; Eastern Regional Research Laboratory; Northern Regional Research Laboratory; Southern Regional Research Laboratory; and Western Regional Research Laboratory.

The work of the Bureau of Agricultural Chemistry and Engineering is supported by various subappropriations in the Department of Agriculture Appropriation Act, including: Items for the regular projects of the Bureau; a specific sum for the Regional Research Laboratories in the item for Conservation and Use of Agricultural Land Resources; and the Special Research Fund item for carrying out the purposes of the Bankhead-Jones Act, from which allotments are made to the Bureau.

The more important results of the Bureau's work during the fiscal year 1941 are reported in the following pages. The reports on particular subjects are in most cases arranged under headings corresponding to financial projects, rather than to divisional and laboratory organization, as has been the practice in recent years. Further information concerning many of the subjects discussed may be obtained from the 252 publications issued during the year and listed at the end of this report together with a list of 7 patents issued to members of the Bureau personnel.

AGRICULTURAL CHEMICAL INVESTIGATIONS

VEGETABLE PRODUCTS

After conferences with representatives of the Subsistence Division of the Quartermaster Corps of the Army, the fruit and vegetable chemistry laboratory in Los Angeles has been engaged in attempts

to produce dehydrated vegetables of more satisfactory quality than those now available. The Army has expressed particular interest in dehydrated potatoes, sweetpotatoes, onions, carrots, and cabbage. For Army purposes it is essential that the products maintain as nearly as possible the texture, odor, and flavor of the fresh vegetables. It is also highly desirable to maintain the vitamin content of the raw product. With these objects in mind, a large number of samples of these vegetables have been prepared and tested as to their rates of rehydration and the quality of the cooked product. Many variations of standard practices have been carried out, and information has been acquired that will be the basis of the more extended operations conducted under direction of the special dehydration committee of the Bureau.

The Pullman, Wash., laboratory has continued cooperative work with the Washington Agricultural Experiment Station, at Prosser, Wash., and has selected varieties of vegetables, grown under irrigation in the area, that are most suitable for preservation by canning. The experimental packs prepared are being examined from time to time, and definite recommendations as to satisfactory varieties will be made.

Studies were continued on the preservation of vegetables by quick freezing at the laboratory in Seattle. At the close of the fiscal year these investigations were transferred to the Western Regional Research Laboratory at Albany, Calif. Studies carried on at the Seattle laboratory have shown that for the first few months the manner of packaging of quick-frozen vegetables is not important. For periods in excess of 6 months, however, airtight packages that are both moistureproof and moisture-vaporproof are necessary. The experiments confirmed the prevailing idea that storage at the lowest possible temperatures is desirable. A comparison of peas stored at 15° and 0° F. indicated that the former lost more in weight and in vitamin content than the latter. Weight losses approximating 5 percent are accompanied by deterioration in quality noticeable both in color and texture changes.

Studies were continued on the possibility of using the tenderometer for testing the quality of vegetables to be used for freezing preservation and also the quality of the frozen products. The data obtained from a large number of experiments are being critically studied in order to make definite recommendations regarding use of this instrument. It is believed that it will be possible to use the instrument in such a way as to reduce arguments between growers and processors, and to work out an equitable method of payment to the growers for raw materials.

In order to obtain satisfactory quick-frozen corn, it is essential that the crop be harvested at exactly the right degree of maturity.

A completely satisfactory test for the maturity of corn for preservation by freezing is not yet available. Preliminary studies have indicated that the viscosity of the juice pressed from the kernels may be satisfactory for this purpose, as there is a high degree of correlation between the juice viscosity and the moisture content of the corn. The moisture content has been used to a considerable extent as a criterion of quality, but its determination requires much more time than does that of the juice viscosity..

The Seattle laboratory has cooperated with the Agricultural Marketing Service in the development of quality standards for frozen cut corn. There has been similar cooperation in connection with standards for frozen asparagus and lima beans.

It has been shown that blanching corn prior to freezing is necessary in order to prevent undesirable changes in color and flavor. Tests to select varieties of corn suitable for freezing have been conducted in cooperation with the Western Washington Experiment Station. Four selections, namely, Tender Red Cord Chantenay, Streamliner, Nantes, and Improved Coreless were considered the best of the nine varieties tested.

The Seattle laboratory has examined bacteriologically a large number of samples of frozen vegetables. At present it is impossible to state a limit or tolerance for bacteria in such products. Many commercial plants produce frozen vegetables containing less than 300,000 organisms per gram. When the content runs above 500,000 per gram on glucose agar, there seems to be reason to suspect the sanitary conditions in the plant. The laboratory has developed a direct microscopic test for bacteria in frozen vegetables that has possibilities for control purposes. This is somewhat similar to the "Breed count" in milk, which is used as a method of sanitary control of fresh milk.

The conservation and storage of perishable food products is now of particular national importance. One of the methods of storing food products for future use is by bulk salting and fermentation. Approximately 5 million bushels of cucumbers are salted each year and preserved for future use. The work of the Bureau in this field has been directed to the elimination of spoilage resulting in the formation of soft, bloated, and improperly cured pickles, and to the development of new processes designed to reduce waste and loss.

During the year investigations on the production of cucumber pickles under southern climatic conditions were continued in cooperation with the Department of Horticulture of the North Carolina Agricultural Experiment Station. They included chemical and bacteriological studies directed to the production of satisfactory salt stock in the vats of a collaborating commercial concern. Examination of the 1940 salt stock after a curing and storage period of about 10 months revealed that it was somewhat superior to that of 1939. In general, the results of this year's work on salt stock showed that duplicate lots of cucumbers receiving the same salting treatment were similar in firmness and other qualities and that lots started in brine of 60-percent saturation were inferior to those started in brines of 20- to 40-percent saturation.

Further experiments on the preparation of genuine dill pickles in North Carolina demonstrated that most of the firmness can be retained for 18 months or more when proper methods of pasteurization are used. Since, according to a recent survey, the softening of dills is not restricted to the South, this discovery is important to the entire domestic pickle industry.

The Bureau's discovery that hydrogen-forming micro-organisms are involved in the production of hollow cucumber pickles, or "bloaters," has been reported previously. In the search for the particular organisms responsible for these inferior pickles, 29 strains of

microorganisms were isolated from cucumber fermentations in salt brines ranging from 20- to 60-percent saturation. Morphological, cultural, and physiological characteristics placed 20 of these strains in the genus *Aerobacter*. They conformed more closely to the *cloacae* species than to the *aerogenes*.

Studies of the gaseous fermentation brought about by *Aerobacter* bacteria in cucumber fermentations in brines of 20-, 40-, and 60-percent saturation showed that the 60-percent-saturated brine was most conducive to active hydrogen formation. The rate of gas evolution, and the composition of the gas at different periods during the fermentation, demonstrated that typical fermentations in both 40- and 60-percent-saturation brines were divided into two distinct gas-evolution phases. During the first period of active fermentation, which was brought about by the *Aerobacter* group, the ratio of hydrogen to carbon dioxide was about 1:1, whereas during the second phase of gas evolution, brought about by yeasts, the gas was practically all carbon dioxide. The importance of this work lies in the fact that a cucumber pickle that becomes a bloater through the action of these types of gaseous fermentation has a value of only one-half that of the normal firm product.

The cooperative development of a new type of bottled fresh cucumber slices has previously been reported. The commercial production of this product is increasing. The outstanding characteristics of the product are its crispness and freshness, and it has been demonstrated that these qualities are retained only through carefully controlled pasteurization followed by rapid and effective cooling. The results of bacteriological studies in the preparation of these fresh cucumber slices have been summarized and published. They show (1) that a considerable population of acid-forming bacteria and yeasts is built up during the overnight soaking of the cucumber slices in a 30-percent-saturated brine, (2) that these acid-forming micro-organisms generally survive the application of the hot liquor to the slices, but (3) that they are killed by the pasteurization at 160° F. for 20 minutes or at 165° F. for 15 minutes and only the resistant, spore-forming, nonspoilage types of bacteria survive. The general conclusion is that adequately controlled pasteurization must be employed or spoilage will result.

One of the next steps in the program is to apply the knowledge and experience gained in the research on cucumbers to the satisfactory salting, fermentation, and processing of other types of vegetables. No doubt these methods of preservation will become more important in filling local, as well as national, needs in the period ahead.

FRUIT PRODUCTS

The production of canned orange juice continues to increase, largely because of improvement in the quality of the product. Not less than 7 million boxes of oranges were used for this purpose in the 1939–40 season. The diversion is helpful to the grower, since it reduces the quantity of oranges that must go to the fresh markets. Although an acceptable canned orange juice has been developed, it has a somewhat limited shelf life and the flavor is not quite so good as that of the fresh juice. At the Winter Haven, Fla., laboratory, work has been continued in an effort to reduce these deficiencies. Experimental evi-

dence indicates that the off-flavors which develop during storage are partly due to the oxidation of the traces of fixed oils or fats suspended in the juice. The studies have been directed (1) to the nature of the changes, apparently oxidative, that take place, and (2) to the development of methods of preventing such oxidation. Because of the minute quantities of reacting materials present and the complex chemical reactions involved, progress is necessarily slow.

As a byproduct of these investigations, it has been noted that although there is a slightly better flavor in canned orange juice packed in enameled cans, the difference is so small that it probably would not be noticed by most consumers. It, therefore, appears probable that plain cans rather than enameled cans can be used for orange juice, with a resulting decrease in total cost. This decrease, if reflected in consumer prices, might result in some expansion of the market.

The Los Angeles laboratory has shown that the retention of vitamin C in orange juice depends largely on the rapidity with which the juice is handled from the time it is taken from the fruit until it has been processed in the sealed can. It has also been shown that the higher the storage temperature of the canned article the more rapid is the loss of vitamin C. In view of the widespread interest in vitamins, which has been increased by the recommendations of the National Nutrition Conference for Defense, any developments that lead to the retention of naturally occurring vitamins in food products are of real importance to the people of the country.

The juice of oranges as produced in the home is naturally cloudy, and the public is accustomed to and desires a similar cloudiness in the commercially canned article. Experiments at Los Angeles have shown that flash pasteurization of the orange juice at a relatively high temperature not only promotes the retention of vitamin C, but very directly results in the production of an article having the desired cloudy appearance and maintaining it over a considerable period.

The Los Angeles laboratory has cooperated with the California Fruit Growers Exchange in the development of beverage bases composed of dried skim milk with dried citrus juice. Powdered products made from either mixtures of dried citrus juice and skim-milk powder, or the product resulting from the drying of mixtures of citrus juices and concentrated skim milk have been prepared. When mixed with sugar and water these powders make palatable and highly nutritious beverages and are valuable as a means of supplying both vitamins and milk solids in the diet. From the economic side, under normal conditions they offer an outlet for both skim-milk powder and low-grade citrus fruits. Such concentrated products might be useful in making food shipments under the Lend-Lease Act and also in military food rations.

Several years ago the Winter Haven, Fla., laboratory demonstrated the possibility of manufacturing oil from grapefruit seed. This product, which has been developed commercially, was found to be particularly valuable in certain operations in the textile industry. As a result of numerous inquiries regarding the possibilities of using orange seed as a source of oil, the Winter Haven laboratory has prepared and examined samples of orange-seed oil, and has found that it might be useful either as food or for other purposes. From 1 ton of

air-dried seed about 570 pounds of oil and 1,240 pounds of press cake can be made. In canning orange juice under the usual factory conditions, however, the seeds are not separated, and to obtain sufficient quantities to carry on commercial operations it would probably be necessary to concentrate the separated seeds from a number of canneries.

The Winter Haven laboratory has carried on further investigations of the possible utilization of citrus waste from factories producing citrus cattle feed. By using controlled-fermentation methods, lactic and butyric acids have been prepared. The method for making the former has been developed to such a point that application for a public-service patent has been made. Industrial alcohol can be obtained and, as a byproduct, yeast, which when dried is a valuable stock feed of a highly concentrated nature. The same laboratory has shown the possibilities of producing other valuable chemicals, such as paracoumaric acid and phloroglucinol from naringin, a constituent of grapefruit skins, which are a waste product from the factories packing grapefruit juice and grapefruit segments.

From time to time shipments of shelled pecan meats have been seized under food regulatory laws because of the alleged presence of harmful bacteria. The Weslaco, Tex., laboratory has been successful in developing a treatment that not only removes this defect but improves the appearance of the nuts. The treatment consists in soaking the meats in a strong solution of sulfur dioxide, followed by washing and vacuum drying. The method is not intended to mask defects due to insanitary conditions in the nut-cracking plants, but instead to insure that the products going into the market shall be of the highest quality.

For a number of years grapefruit juice, containing some juice cells, packed in barrels, and preserved with sulfur dioxide, has been shipped from Texas to Great Britain for use in making beverages sold as "smashes." This method of preservation has not been used on any other products in this country. In connection, however, with Lend-Lease Act shipments of strawberries, at the request of the Surplus Marketing Administration, the Weslaco laboratory has given assistance in the packing of strawberries for shipment to England, using this method of preservation.

An attractive beverage has been made from fresh Italian prunes by the Pullman, Wash., laboratory. The product is of the pulpy type generally sold as "nectar" and has the characteristic flavor and odor of fresh prunes. One packer has put up a thousand cases for a market test. This laboratory has continued its investigations on the development of combinations of fruit juices, sirups, and concentrates with milk for the preparation of food drinks that have more appeal to children than milk alone. A group of school children were given a choice of plain milk, chocolate milk, milk containing artificial raspberry flavor, and milk flavored with various pure fruit products. A definite preference was shown for milk flavored with youngberry, with the raspberry-flavored milk a close second. In general the most satisfactory and economical drinks of this type were those made with the sirups of fruits having a strong flavor and a low acid content.

Experience has indicated that the highly clarified apple juices are not preferred by consumers because they lack sufficient body. By

modifying the various steps in the processing of apple juice, particularly the filtration and clarification, juices have been developed that more nearly approximate in consistency the juice obtained directly from a cider press. Naturally, the more highly flavored apples produce juices that retain more of the characteristic flavor of apple juice. However, there is a possibility of blending juices of different varieties in order to obtain uniformity of flavor and to use the more lightly flavored apples, larger quantities of which are available.

Reorganization in the work of the Bureau made it necessary to discontinue the work on fruit juices, which has been carried on cooperatively with the New York Agricultural Experiment Station at Geneva. The work was stopped and the cooperative agreement terminated at the end of February. The permanent personnel of the staff and the equipment of the laboratory have been transferred to other field laboratories in the Bureau. During the period of the fiscal year that the Geneva laboratory was operating, it was found that frozen strawberries and raspberries could be used for blending with other fruit juices without any loss of color or flavor. This information has practical value, as it opens up previously unknown possibilities of blending fruit juices.

The Geneva station experimentally tested a semicommercial pack of blended apple and raspberry juice. This was sold through a local chain store, and consumer reactions to it were obtained. The product consisted of 75 percent of apple juice and a mixture of black and purple raspberry juices with sufficient sugar to make it palatable. Consumers were enthusiastic about the product, and it appears that commercial production will be developed. A "cherry cocktail" has been tested in a similar way, and after hearty acceptance by consumers, commercial production has been undertaken.

The frozen-pack laboratory in Seattle, Wash., has carried on further investigations on the preservation of fruits by freezing. The darkening of peaches during preparation, freezing, or thawing is one of the objections to the preservation of this fruit by freezing. The use of halved peaches in place of slices reduces the discoloration to some extent, but no thoroughly satisfactory method has yet been developed.

The production of frozen sliced apples for pie bakers is increasing. The flavor closely approximates that of the fresh fruit, and the texture is more satisfactory than that of any other type of preserved apple. Bacteriological examinations of the slices show a large decrease in the bacterial content as a result of freezing. The presence of more than a few thousand bacteria per gram in the frozen product would indicate insanitary conditions in a factory where such a product was prepared.

The same laboratory has examined bacteriologically a large number of commercial samples of quick-frozen fruits. The organisms found ran from as low as 1,000 to as high as 30,000 per gram. Variations were large and frequent, not only from factory to factory but also in the products of individual factories. Furthur study may lead to the establishment of a satisfactory criterion of sanitary quality in quick-frozen fruits

The Seattle laboratory has made a number of experimental packs of quick-frozen fruits with sugar and honey and mixtures of the

two. Examination of these samples will indicate the possibilities of the use of these sweetening agents with regard to color, flavor, and bacterial content.

The Seattle laboratory has cooperated with the Irrigation Branch Station at Prosser, Wash., and the Oregon Agricultural Experiment Station in studying the suitability of a number of varieties of different fruits for freezing preservation. Under the conditions at Prosser, Wash., it was found that the following varieties of peaches gave satisfactory frozen products: Rio Oso Gem, J. H. Hale, Elberta, Gold Medal, and Late Crawford. In western Washington 4 varieties, namely, Sunbeam, Crawford, South Haven, and Eclipse, were found to be the most satisfactory. As a result of the tests with the Oregon station, 9 of 131 varieties of strawberries were considered to be of sufficient value to warrant more extensive planting and testing.

From time to time disputes have arisen between buyers and sellers in regard to the presence in cold-pack fruit of small white deposits that resemble mold. These deposits appear after long storage. Examination of the material has shown that it is a mixture of fine-grain crystallized sucrose and a small quantity of dextrose, and is not in any way connected with mold. The products containing these deposits are perfectly sound and there would appear to be no reason for the rejection of deliveries on this basis.

CEREAL PRODUCTS

The enrichment of flour has been given a great deal of attention in the last year or two. A true whole-wheat flour would, of course, carry all the vitamins and minerals of the wheat berry. This product, however, deteriorates more rapidly than white flour. Furthermore, many people do not like whole-wheat bread. There is a possibility of improving the nutritional value of white flour by the incorporation of wheat germ. The cereal laboratory has examined a large number of samples of wheat germ from different parts of the country and has made very satisfactory breads with 15 percent of germ and 85 percent of clear flour. Such breads contain most of the vitamins of whole-wheat bread and about 75–80 percent of the minerals. It has been shown that soaking of the wheat germ for several hours prior to mixing it with the flour gives a more satisfactory loaf. A wheat-germ bread would go far toward meeting nutritional ideals, particularly as set up by the recent National Nutrition Conference for Defense.

Studies of the effect of storage between 0° and 70° F. on wheat and on flour have been continued. Experiments show that within this temperature range there is little or no change in the wheat as measured by the flour made therefrom, provided moisture content is not excessive. Stored over the same time and under the same conditions, however, there is considerable deterioration in the flour, which increases with rises in the moisture content of the flour. A similar experiment, in which the wheat is stored at temperatures of 70°, 80°–85°, and 100°–110°, has been started. It will be of interest to determine whether there is any marked deterioration in wheat stored at these temperatures, as the upper ranges will be comparable with those to which large quantities of wheat are now subjected in the galvanized-iron bins located throughout the wheat-producing areas. If it is

found that the wheat deteriorates or that flour made from such wheat will not produce satisfactory loaves, unquestionably some other method of storage must be devised in order to make the Ever-Normal Granary workable.

Samples of wheat flour were subjected to compression under pressures as high as 16,000 pounds per square inch. After storage over a period of several months, it was found that the loaf volume of the bread made from this flour had decreased by 15–20 percent, as compared with that of bread made from the uncompressed flour. This reduction in volume is not enough materially to affect palatability. By such compression it is possible to increase the specific gravity of the flour from about 0.6 to 0.9 or to reduce the volume of the flour by about one-third. This reduction is, of course, a matter of considerable importance in overseas shipments and for military use. Experiments are now under way to determine whether the compressed flour can be handled in the bakery in such a way as to produce larger loaves more nearly comparable with those made from uncompressed flour.

Storage experiments with whole corn meal have shown that at 70° F. and with no more than 13½ percent moisture such meals can be stored in airtight containers for about 1 year. With a moisture content as high as 16 percent, they can be stored for as much as 2 months in ventilated containers, such as paper bags, at temperatures as high as 100°.

Deterioration in cereal products is frequently due to rancidity of the small quantity of oil present. A test for detecting incipient rancidity has been developed. With this knowledge it will be possible to put products showing incipient rancidity into consumption before they have been seriously damaged. Previous reports have mentioned the "chlorophyll value" test developed by the Bureau for this purpose.

EGGS AND EGG PRODUCTS

The poultry and egg industry is one that concerns almost every community. Its return to the farmer is valued at more than 1 billion dollars a year. Eggs are essential in an adequate diet and naturally became one of the first food materials requested by the British for shipment under the lend-lease program. Since refrigerated space for shipment has become almost nonexistent, and it is most economical of space and handling to ship concentrated foods, attention has turned to the production of dried eggs. The Surplus Marketing Administration was charged with buying large quantities of dried egg products for shipment to Great Britain, and at their request work was undertaken by the Bureau in the fields of bacterial content, sanitation, methods of production, and retention of quality during storage.

The bacterial content of each lot of dried eggs prepared for shipment is being determined in order to obtain information on the quality of the product and on the operation and expected performance of American egg-drying plants. Considerable time has been spent in evaluating experimental lots of dried-egg products prepared by special equipment and by new methods, in order to obtain data for new plants and new processes needed in expanding the production program.

Since the bacterial content of egg products may be used as an index of the sanitary conditions under which the material has been pro-

duced or stored, the work has an important bearing not only on the final product but also on all phases of handling and processing. Accordingly, at the request of the Institute of American Poultry Industries, the Bureau has undertaken research to develop a suitable method for detecting eggs having exceptionally high bacterial counts. It is believed by the Institute that eggs having very high bacterial counts escape detection during the breaking-out process and cause contamination and high bacterial counts in large batches of frozen eggs and other products. This problem is being investigated in cooperation with the poultry farm of the Bureau of Animal Industry at the Agricultural Research Center in Beltsville, Md. Eggs from several flocks of hens maintained under different controlled conditions that may be factors in bacterial contamination are being examined systematically with a view to locating sources of infection. Of a large number of eggs examined, a little more than 1 percent were found to be infected with bacteria at the time they were laid. Bacterial counts for these exceptional eggs ranged from 40 to 215,000 per cc. of mixed egg material. Other eggs laid by the same hens were found to be bacteriologically sterile.

Since only a few of the eggs found to contain viable micro-organisms at the time of laying contained enough to contaminate large batches of egg mix, the tentative conclusion was that eggs containing bacteria when laid are probably not the cause of high bacterial counts in occasional batches of frozen eggs. It was also concluded that hens do not consistently lay eggs having bacteria-infected contents, but produce them only occasionally.

In view of these facts it seems probable that the cause of high bacterial counts in eggs lies in methods of handling during storage and breaking-out in the freezing and drying plants. This information has added importance at present, when the conservation of food and the maintenance of quality are of vital interest to all.

At the request of the Surplus Marketing Administration the Bureau has started an investigation of the preservation of edible liquid egg yolk without benefit of refrigeration for shipment to Great Britain. In the past a liquid egg-yolk product containing glycerin was prepared in China for the European trade. This product was essentially a homogenized 9:1 yolk-glycerin mixture that had been dehydrated sufficiently to reduce its weight by about 30 percent. About 1 percent of borax or other preservative was added to enhance the keeping quality of the product. Because of immediate need for egg products in Great Britain, research was directed particularly to the preparation of such a product by partial dehydration and use of harmless preservatives. A successful method of packing edible liquid egg products without refrigeration is also of value for Army and Navy use. It would also make possible large-scale shipment of such foods to European countries where they are in demand, thus furnishing an additional outlet for American agricultural products.

The Bureau has also been requested to cooperate in the development and evaluation of canned poultry products for shipment to hospitals in England and Egypt. It is anticipated that more than 5 million pounds of canned poultry will be needed, and in view of its destination the maintenance of keeping quality and nutritional value is of great importance.

The expansion of the dried-egg industry has given added importance to the production of dried-egg albumen. Unless the small quantity of natural sugar is removed from the raw egg white the color of the resulting dried product will darken rapidly on storage. The sugar may be removed by fermentation, but unless this is carefully controlled an inferior product may result. Research has been undertaken to develop methods of microbiological control in such fermentations and to insure dominance of desirable bacteria to produce a uniform, superior, and soluble dried albumen. Preliminary work has shown that certain types of bacteria predominate in natural and normal fermentations and that the course of the fermentation is governed largely by the types of bacteria that predominate in the broken-out egg white. In normal fermentation there is no evidence of proteolysis, whereas most abnormal fermentations show marked proteolysis. It has been shown that fermentations can be controlled by the use of pure cultures of bacteria and the proper pH value and temperature.

SUGARCANE AND CANE SUGAR

Sugarcane grown for production of sugar in Louisiana and Florida is cultivated on 300,000 acres and has a crop value of about 20 million dollars. In addition to its utilization for the production of sugar and molasses, it has been found that under present conditions this crop can supply two byproducts of particular importance and value. These new products are sugarcane wax and aconitic acid. A part of the Bureau's current work in this field has therefore been devoted to devising methods for their efficient recovery as byproducts of sugar manufacture.

The research on wax is of especial interest at this time because of the present serious shortage of waxes in the United States resulting from interruption of imports. Waxes are used in the production of a great variety of articles, some of which are of critical and strategic importance. The Navy uses a quantity of waxes, and the Navy Department has suggested to the Bureau the desirability of developing a supply of sugarcane wax in the United States. The results of tests indicate the suitability of sugarcane wax for most domestic uses.

This wax, which is found on the surface of the cane stalk, is largely dislodged and flushed off in the milling operations, becoming dispersed in the juice and subsequently collected in the clarification settlings or "muds" during purification of the juices. It is further concentrated in the filter-press cake along with a variable proportion of the natural fats of the cane. Comprehensive studies of the solubility of cane wax in different organic solvents have been made, and other properties of the wax have been determined. Preliminary experiments have indicated that 7–17 percent of the weight of the dried press cake may be obtained as wax. A solvent extraction process has been devised and is now being developed on a pilot-plant scale. It is indicated that millions of pounds of this wax can be recovered annually from the sugarcane processed in continental United States.

Aconitic acid is the principal organic acid in sugarcane and sorghum cane. Its calcium salt, formed by reaction with the lime used

in clarification of the juice, frequently crystallizes out of the sirups in the sugar process as a sediment that causes fouling of heating surfaces and difficulty in sugar production. The properties of calcium aconitate have been investigated in order to determine the most practical method of avoiding these difficulties in sugar production. For recovery of aconitic acid as a byproduct, molasses appears at present to be the best source, as the acid accumulates there as a salt in quantities as high as 6 percent. This investigation has also shown that aconitic acid occurs in relatively large quantities in the discarded tops of the cane; hence the possible utilization of cane tops for recovery of aconitic acid is also being studied. The solubility and nature of the different salts in which aconitic acid is precipitated are being investigated as a basis for developing a method for recovering the acid commercially.

Aconitic acid is of value as a plasticizer in the manufacture of plastics, the acid now available for this purpose being produced synthetically in limited quantity from citric acid at higher cost than that recoverable from sugarcane. In view of the present urgent need for increased use of plastics to conserve strategic metals in the production of numerous lightweight articles a large supply of aconitic acid from natural sources is important. The quantity of aconitic acid recoverable from sugarcane in the continental United States alone may be expected to run into millions of pounds annually.

Small quantities of starch cause considerable difficulty in sugar manufacture, since the starch becomes gelatinized on heating and greatly increases the viscosity of the resulting massecuites and molasses, thus reducing sugar crystallization. Estimations of the starch content of cane juices in Louisiana indicated that sufficient quantities were present at times to be significant in the clarification and workability of the juices. Distinct differences were found in the starch content of different varieties of sugarcane grown in different sections. A method for correcting this difficulty is being sought.

In continental United States much of the sugarcane must be windrowed to protect it from freezes. Adequate knowledge of the nature of such damage, of the conditions influencing it, and of sugarcane varieties best suited for windrowing is important. Investigation along these lines was conducted in cooperation with the Bureau of Plant Industry. As a result of two early freezes, November 15 and 16, 1940, in the Louisiana sugar area, about one-half the sugarcane crop was damaged in varying degrees. Cane that had been windrowed before the freezes kept excellently, and that windrowed after the first freeze deteriorated less than that left standing or that windrowed after the second freeze. Cane left standing developed acetic acid at a somewhat faster rate than cane subjected to the same low temperatures, but windrowed immediately after the second freeze. However, both fermented at a much slower rate than is sometimes experienced, thus making it possible for the factories to complete the season's work without serious difficulty. The deterioration of the cane induced by these freezes, which were followed, as usual, by warmer weather, was principally a normal alcoholic fermentation with consequent loss in value of the cane. This type of fermentation does not cause serious factory operating trouble. Factory experience and observations of results of freezes in this and

other years, together with accumulated information on the properties of different varieties of sugarcanes and methods of harvesting, may be expected to lead to more efficient harvesting methods in the sugarcane areas.

In the continuation of an investigation to determine the causes of color formation in sugarcane juices, sirups, and sugars, it was concluded that decomposition and color formation increased with an increase in hydroxyl-ion concentration but not in direct proportion to it. Usually, the decomposition and discoloration brought about by heating mixed sugar solutions with salts that hydrolyze to form alkaline solutions were accompanied by a drop of alkalinity, indicating that the decomposition products were acidic in character and tended to neutralize the alkali. These changes took place to only a minute degree with sucrose alone but were pronounced with the presence of dextrose or levulose, indicating that the reactions are those of the reducing sugars rather than of the nonreducing sucrose. Decomposition of the reducing sugars by the hydroxyl-ion during heating can be avoided by working at a lower pH value, although too low a pH will cause a loss of sucrose by hydrolysis. Further information along these lines is needed for the development of more efficient methods of producing sirup and white sugar.

SUGAR BEETS AND BEET SUGAR

Roughly, 1 out of every 5 pounds of sugar consumed in the United States in beet sugar produced from sugar beets grown in 17 States. Close to a million acres are used for this crop, the crop value being about 60 million dollars. Besides sugar, the beets furnish byproducts important to the dairy and cattle industries.

In cooperation with the industry, studies were continued on the chemical, physical, and biochemical factors of the sugars produced in 1940, and the results have been reported to the industry as a basis for further progress. The role of organic salts was presented for the first time.

The bacteriological quality, which is of especial importance in sugar for the food industries, was determined with respect to thermophilic and mesophilic organisms. Cooperative assistance was given when difficulties in biological control were encountered.

Because of the necessity in many areas of harvesting the beets before they become frozen in the ground, the harvesting rate is much faster than that at which the beets can best be processed, and it is customary to store a large proportion of the crop in piles for 30 days or more. During storage, sugar is consumed, and therefore lost, by respiration of the beets, and nonsugar compounds are formed that cause a reduction in the recoverable yield of sugar in processing. Furthermore, some losses occur because of actual spoilage of the beets. It has been estimated that such losses amount to more than 5 million dollars a year, and means of restricting them are of corresponding importance to the general economy of the industry. Investigation of this subject has been undertaken.

FARM-MADE SIRUPS AND SORGO SUGAR

About 40 million gallons of farm-made sugarcane, sorgo, and maple sirups are produced annually on some 500,000 small farms in

the United States. Since about 60 percent of the total production is marketed, these sirups add materially to the farm income, but because of variation in quality, farm prices vary greatly, and some sirup is actually unmarketable. There is an excellent demand at profitable prices, however, for sirups of consistently good quality, and the market will absorb considerably more of such sirups than is now produced. Many consumers who are fond of farm-made sugarcane or sorgo sirups discontinue their use for a time when they obtain sirups of unattractive flavor and color. Such interruptions in the use of sirups by many individuals are a great handicap to successful marketing.

The value of these crops in diversified farming and for subsistence purposes is often underestimated. Harvesting and processing are both done on the farm during a period of the year when labor is not needed elsewhere. Although constituting a minor crop as compared with cotton, corn, wheat, etc., farm-made sirups play an important role in the economy of underprivileged families operating widely distributed small farms in the United States. Many of these farm families use as much as 50 gallons of home-made sirup a year, thus saving the much needed cash that would be required to buy its equivalent. For home use, also, the sirup must be of satisfactory quality.

Investigations were conducted during the year on the various factors governing yield and quality of sirup, attention being given particularly to means of preventing or avoiding the objectionable flavor and unattractive appearance of some sirups made on the farm. Sorgo and sugarcane sirup investigations were conducted at the Auburn, Ala., field station in cooperation with the Alabama Agricultural Experiment Station and its substations, and with the State Extension Service. Similar work on sorgo sirup was done in Georgia in cooperation with the Georgia Mountain Experiment Station, a substation of the Georgia Agricultural Experiment Station. In order to determine how greatly sirup quality and yield may be influenced by varietal, cultural, and maturity factors, chemical examination was made of the juices and sirups from sorgo and sugarcane of different varieties grown on different types of soil, treated with different quantities of fertilizer, and harvested at different stages of maturity. The sirups were also graded according to color, taste, clarity, and yields per ton and per acre. A standard method of making the sirup was used so that differences between the sirups were definitely due to the character of the cane and not to variations in processing conditions. The results gave much information regarding the influence of agronomic conditions on the yields and quality of the sirup. It was indicated that by using proper methods, sirup of reasonably good color and flavor could be made from most of the varieties of sorgo and sugarcane grown in Alabama on the different soils of the Experiment Station and substation plots. Sirup of good quality also was obtained from a number of the better varieties of sorgo grown in the northern part of Georgia.

Practically all the sirups made at the Auburn Station contained sediment, which separated gradually on standing, although several samples from completely fertilized plots contained only small quantities. The sirups from some of the completely fertilized plots, however, contained the greatest quantities of sediment. It was observed that the quantity

of sediment varied more with the type of soil and stage of maturity at which the cane was harvested than with variety. In the case of sorgo, sirup of the greatest clarity was made from the crop when in the "late dough" and "medium ripe" stages of maturity. It was found that during storage of the sirup samples the pH and titratable acidity values had changed somewhat, although it has not yet been possible to correlate these changes with the quantity of sediment in the sirups. It is possible that during storage the flocculation of certain nonsugar substances, with production of sediment, may be associated, in part, with these acidity changes.

Since the flavor of sugarcane sirup is influenced by volatile constituents, a method of evaporation designed to remove objectionable volatile constituents was tested. In this method live steam was passed through the boiling juice during evaporation. It was found, especially in sorgo juices, that the volatile acids (such as are produced by fermentation following a freeze) were removed more completely by this method than by the customary evaporation method. During the 1940 season early freezes damaged much of the sugarcane crop throughout the South to such an extent that it was unfit for making sirup by the customary method. It is believed that the evaporation method mentioned will be of value in making possible production of satisfactory sirup from sugarcane and sorgo damaged by cold weather.

Emphasis in the sorgo investigations was shifted during the year from table sirup to the production of crystallized sugar from this crop. During the harvesting seasons for sugarcane and sugar beets, freezing weather frequently causes severe losses of these crops and also considerable difficulty in manufacturing, resulting in a slowing down of operations and a reduction in sugar yields. The harvesting season for sorgo, however, is earlier, so that a partial substitution of sorgo for sugarcane and sugar beets would enable the industry to start harvesting sugar crops earlier, thus eliminating some of the losses that result from freezing.

In the sorgo-sugar investigations of the past year, which were conducted in cooperation with the Bureau of Plant Industry at its field station near Meridian, Miss., the experimental process for recovering and purifying sugar from sorgo juices was developed to the point where it was possible to obtain as high a percentage recovery of sugar as from sugar cane of average quality. In addition to the adverse effect of starch, which has been previously reported, it was found that the presence at times of salts of aconitic acid interfered seriously with sugar recovery. Methods were developed for separating at least 85 percent of the starch and a considerable percentage of the calcium salts of acotinic acid. Up to 10 pounds of starch and 3½ pounds of aconitic acid per ton of cane were recovered during the process of manufacturing sugar, making possible a more efficient sugar process and valuable byproducts. Both the starch and the aconitic acid of sorgo juices may now be considered byproducts of sufficient value to more than offset the cost of removal during the sugar-production process.

Several varieties of sorgo tested at Meridian had a sugar content as high as standard Louisiana sugarcane. The earliest variety matured during the first part of July and the latest variety during the latter part of September, indicating that should sorgo be successfully

substituted for a portion of the sugarcane the date for completing harvesting could be advanced at least 1 or 2 months to reduce losses now caused by freezing. It is also possible that a partial substitution of sorgo for sugar beets might be made with comparable saving.

Maple-sirup grading standards were prepared for the Agricultural Marketing Service and, as usual, master sets of these standard colors were supplied to various States. The standard colors are now in widespread use for grading sirups both by farm producers and by buyers and packers of maple sirup.

HONEY

Beekeeping contributes more to American agriculture than is represented by the quantity of honey produced, although this amounts to between 150 and 200 million pounds per year and has an estimated farm value of about 12 million dollars. In addition to the value of honey and beeswax as cash crops, the beekeeping industry is worth many times (one authority says 15 times) this amount to agriculture through the pollination of crops. The production of important orchard fruits and legume seeds, for example, is dependent upon pollination by honey bees; and the production of these legume seed crops, which include alfalfa, clover, and soybeans, is essential to the national pasture, hay, and soil-building programs.

But the welfare, even the maintenance, of the beekeeping industry depends in large part on success in marketing the honey crop. Market demand and prices for honey determine whether the practice of beekeeping increases or decreases, and affect, in varying degrees, the economic life of not far from a half million beekeepers in the United States. In order to increase, or even maintain, the market demand for honey, potential consumers must be acquainted with the characteristics, composition, and properties of domestic honeys, and the special advantages of definite types of honey for particular purposes; and honeys of specified types and uniform quality must be available.

Since nearly half the honey produced is consumed by various industries, chiefly the commercial baking, confectionery, and other food industries, and an increase or decrease in these industries would have the most effect on market demand, the research on honey has been directed especially toward learning the suitability of honeys of different floral types for known or possible industrial uses. The systematic investigation of the chemical and physical characteristics of representative American honeys has been continued, the information being used to determine the utility of these honeys, of distinct floral types, with respect to the special requirements of the different food industries.

A survey was made of honey utilization by commercial bakers in four large eastern cities and a part of Chicago, and, in cooperation with the Honey Utilization Committee of the American Honey Institute, a report was presented at the National Beekeeping Conferences at Omaha, Nebr. This report advocated a utility classification of honeys for the bakery trade, with the object of providing bakers with definite types or blends of honey, each of which would have greater uniformity, better defined characteristics, and improved quality, in comparison with honeys now available. The report made available

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authentic information on the honey requirements of commercial bakers and specified the characteristics of honeys that are either essential or desirable to make them readily acceptable to the baking industry.

In cooperation with the Bureau of Dairy Industry, experimental work was conducted to determine the suitability of several representative commercial honeys for use with milk or whey for the production of concentrated food products. Sufficient laboratory work and semi-plant-scale production were completed to show that certain domestic honeys are well suited for such use and yield products having nutritional and flavor characteristics that may be desirable for special purposes. Studies on the keeping quality of such products and their color changes during the storage are in progress.

Among progressive members of the honey industry there has been increasing realization that more must be learned about the "extra dietary" and health values of honey. So far, these extra values have not been demonstrable from its known content of basic nutrients. There has been a growing demand for more knowledge about the undetermined 4 percent of average honey, in the belief, or hope, that the presence of some substance having therapeutic value or some vitamin fraction or new accessory food substance may be discovered. In recognition of this, laboratory work was conducted attacking this problem of the identity of the unknown minor constituents of honeys.

Several lots of honey were investigated in connection with problems presented by State or Federal agencies, or honey producers' organizations. Among these problems were prevention of, or remedy for, granulation and foam in bottled honey; causes contributing to fermentation of honey in the comb; and detection of honeydew in honey. Information of practical importance bearing upon these problems was obtained and transmitted to honey producers. For example, it was found that fermenting comb honey differed from sound honey produced in the same yard in containing, on the average, special yeast cells and 3½ percent more moisture.

In cooperation with the Association of Official Agricultural Chemists, a study was begun on methods for detecting honeydew in honey and estimating the quantity present.

STARCHES

Sweetpotato starch has made a place for itself in the United States and is selling at a premium for certain uses. It is being used principally by cotton mills, laundries, and certain food industries, particularly bakers and confectioners.

The Bureau continued to cooperate with the organization of sweetpotato growers operating the sweetpotato-starch plant at Laurel, Miss., by furnishing advice and technical assistance. Additional improvements in equipment and operating procedures were made that simplify and increase the efficiency of the starch recovery and purification processes. A somewhat greater percentage of the starch in the sweetpotato was recovered, and the quality of the product was further improved.

Experience in the Laurel starch plant has demonstrated that a sweetpotato-starch factory in that part of the South can operate on freshly harvested sweetpotatoes for only about 100 days in a year.

It is desirable that the operating period be extended in order to distribute fixed charges over a greater volume of production and thereby lower unit cost. This consideration led to the intensification of studies previously undertaken to develop suitable methods of storing sweetpotatoes for starch production.

In further experiments to determine the possibilities of storing sweetpotatoes without drying, and therefore more cheaply, it was observed that only small quantities of certain chemicals are required to inhibit the growth of anaerobic micro-organisms on sweetpotatoes. Thus, if the surface of a semifluid mass of ground and chemically treated sweetpotatoes in a tank is covered with a substance capable of inhibiting the activity of both aerobic and anaerobic micro-organisms, relatively little deterioration occurs. In laboratory tests 40-pound lots of ground sweetpotatoes were treated with 0.15 percent of sodium sulfite, and covered with a layer of sweetpotatoes containing about 3 to 5 percent of sodium chloride, 0.15 percent of sodium sulfite, and 0.02 percent of 2–4–5 sodium trichlorophenate. The sweetpotatoes were well preserved. Modifications of this procedure were also tried with satisfactory results. One of the most striking observations in these tests was the ease with which starch could be separated from the ground sweetpotatoes after being in storage for a few days. Only a small percentage of starch was retained in the pulp, and the color-producing compounds were chemically reduced to such an extent that a white starch resulted without bleaching and with much less washing than was required for untreated sweetpotatoes. It is believed that this type of pretreatment for sweetpotatoes, if successfully developed, would eventually lead to the design of less expensive starch plants.

At the close of the fiscal year 1941 all work on the industrial utilization of sweetpotatoes was transferred to the Southern Regional Research Laboratory, at New Orleans, La.

A low-cost tray drier for sliced or chipped sweetpotatoes was designed and constructed in cooperation with the Tennessee Valley Authority and Mississippi Agricultural Experiment Station, which are trying to develop profitable uses for waste wood obtained in the stand-improvement thinning of farm woodlots. The waste wood was hogged, and the chips were used as fuel for heating the sweetpotato drier. The furnace was provided with automatic controls. A cossette cutter designed by the Bureau was used for chipping the sweetpotatoes, which were then placed in the drier on trays. This experimental unit produced about 700 pounds of dried sweetpotatoes in 10 hours. This work on the farm drying of sweetpotatoes is being continued.

Assistance was given to a cooperating concern in the design and operation of a sweetpotato dehydrating plant at St. Francisville, La., the equipment and processes used being similar to those developed by the Bureau. The sweetpotatoes were ground, treated with lime, and then pressed to lower the moisture content from about 70 to 55 percent, after which the press cake was dried in two stages. A direct-heat drier was used to lower the moisture content to about 35 percent, and an indirect-heat drier was then used to complete the dehydration. Data were obtained to determine the efficiency of the units making up the plant.

HEMICELLULOSES

Hemicelluloses are complex carbohydrate materials widely distributed in the vegetable kingdom and constitute in many cases as much as 30 to 40 percent of the dry weight of various feeds and fodders, of cereal straws, stalks, vines, roots, hays, and of forage plants in general. Because of the complex nature of the hemicelluloses, knowledge of their composition, constitution, and particularly their nutritive value to farm animals is limited.

Investigation of the hemicelluloses of cereal straws and stalks, hays, and other forage crops and the development of a method for their quantitative estimation were set up as a special research project under the Bankhead-Jones Act.

The method developed for the quantitative estimation of hemicelluloses involves the actual isolation of the hemicelluloses from plant material that has been freed of sugars, starch, pectin, protopectin, and lignin. The plant material is first alternately chlorinated and extracted with an alcoholic solution of ethanolamine until free of lignin. The free and combined hemicelluloses are separated from the holocellulose by exhaustive extraction with 5-percent aqueous sodium hydroxide solution, first at room temperature and then at 100° C. The two hemicellulose fractions are precipitated from the alkaline extracts with acid and alcohol, the weights of the moisture-free and ash-free hemicelluloses are determined, and the percentages of free and combined hemicelluloses calculated.

The results so far obtained in an investigation on hemicelluloses of sugarcane may be summarized as follows: The total yield of hemicelluloses amounted to 14 percent (calculated on the moisture-free and alcohol-benzene-extracted bagasse). When the hemicellulose complexes were subjected to hydrolysis with 2.5-percent sulfuric acid, the only degradation products obtained were *d*-xylose, *l*-arabinose, and *d*-glucuronic acid. The analytical data obtained in connection with the bagasse hemicelluloses were as follows (in percent): Uronic acid (as anhydride), 4.96; total furfural, 55.99; furfural from uronic acid, 0.94; *l*-arabinose, 3.70; furfural from *l*-arabinose, 1.77; furfural from *d*-xylose (by difference), 53.28; *d*-xylose (calculated from furfural), 92.5. The molal ratio of uronic acid to *l*-arabinose and *d*-xylose was 1 : 0.87 : 21.9.

Timothy *(Phleum pratense)* is one of our important forage plants. Although the chemical composition of the timothy plant at successive stages of growth and development has been investigated to some extent, the results have generally been obtained by conventional methods and are recorded in terms of crude fiber, nitrogen-free extract, etc. It is practically impossible to translate such results into terms of definite plant constituents. The chemical composition of the timothy plant at successive stages of growth and development was determined in terms of definite plant constituents, such as cellulose, lignin, pectin, and uronic acids. Inasmuch as no satisfactory direct method for the quantitative estimation of hemicelluloses was available, these carbohydrate complexes were determined indirectly from the total percentage of furfural and the sum of the furfural yielded by the Cross and Bevan cellulose and the uronic acids. The quantities of the various constituents in the tops and roots were determined on a percentage and on an absolute basis, that is to say, as

so many grams of constituent per 100 plants. Some of the more important results obtained may be briefly summarized as follows:

The percentage and absolute quantity of the crude protein in the tops increased rapidly as the plants developed and matured. The quantity of crude protein in the roots showed little variation in the early stages of growth of the plants, but in the later stages the increase was somewhat more pronounced. The percentage and absolute quantity of methoxyl in the tops increased regularly as the plants developed. There was no appreciable variation in the percentage of methoxyl in the roots at successive stages of development of the plants, although the absolute quantity of methoxyl increased somewhat.

The percentage of uronic acids in the tops and roots decreased generally as the plants grew older. The absolute quantities of the uronic acids in the tops and roots generally increased as the plants developed and matured. The percentages and absolute quantities of the hemicellulose, cellulose, lignin, and methoxyl in the lignin increased steadily as the plants grew older. The percentages of pectic substances in the tops and roots showed a general trend downward as the plants grew older.

Cornstalks that had previously been freed of fatty and waxy materials, sugar, starch, and pectic substances and partly delignified by extraction with an alcoholic sodium hydroxide solution were extracted exhaustively at room temperatures with a 5-percent aqueous sodium hydroxide solution. The crude hemicellulose fraction isolated from the alkaline extract was delignified by subjecting it to chlorination and subsequent extraction of the chlorolignin with an alcoholic solution of ethanolamine. The yield of this hemicellulose fraction amounted to 17 percent. On hydrolysis with dilute acid, this hemicellulose fraction yielded *d*-glucuronic acid, *l*-arabinose, and *d*-xylose in the approximate molal ratio of 2:7:19.

The cellulosic material remaining after the removal of the first hemicellulose fraction was successfully extracted in the cold with 10- and 17-percent aqueous sodium hydroxide solutions, and two additional hemicellulose fractions were obtained. These differed quantitatively from the first hemicellulose fraction, although on hydrolysis they both yielded *d*-xylose and *l*-arabinose.

During the past year research on hemicelluloses in the Division of Agricultural Chemical Research was centered primarily on investigation of the composition and methods of separation of the pectin and hemicelluloses of sweetpotatoes and of the hemicelluloses of tungseed press cake and tung hulls (byproducts of the tung-oil industry that may find use as cattle feed). Considerable work was done on the hemicelluloses of sweetpotatoes. Evaluation of these constituents is desirable in view of the great interest now being displayed throughout the South in the possibility of using sweetpotatoes (also sweetpotato pulp, a byproduct in the manufacture of sweetpotato starch) instead of corn as a source of carbohydrates in cattle feed.

The value and agricultural importance of forage and feed crops emphasize the need of more adequate information regarding the function and nutritive value of hemicelluloses and consequently of feedstuffs that contain large proportions of these complex carbohydrates. There is substantial basis for the belief that unsound and

inefficient practices exist in the use of certain forage and feed crops in the feeding of farm animals and that more adequate knowledge of the properties and role of hemicelluloses (which constitute 30 to 40 percent of the dry matter of certain forage crops and feeds) in feedstuffs would have important practical results. The usual feedstuffs analysis gives inadequate information regarding the quantity and composition of the hemicelluloses in feed materials and is of only limited value. Furthermore, in order to determine experimentally the nutritive value of hemicelluloses, it is necessary to isolate them individually from feed materials and feed them separately under controlled conditions. On this basis the actual value to the farmer of feedstuffs containing important proportions of these complexes can be determined.

Because of the relatively high starch content of sweetpotato pulp (byproduct from sweetpotato starch manufacture), it was necessary to remove this constituent before attempting to isolate the pectic substances and hemicelluloses. The starch (constituting about 50 percent of the pulp) was removed by digesting the material with the enzymic preparation Pangestin. The pectin, protopectin, and hemicelluloses were separated from the starch-free material in order to study their composition and nutritive value. Methods of separating and purifying this material into suitable fractions were developed, and feeding tests on each of the individual groups are being arranged with the Bureau of Animal Industry. Small animals are to be used first in the tests and then beef cattle.

In addition to studies on the hemicelluloses of tung meal, an investigation was begun on the composition of the hemicelluloses and other components of the shells from tung nuts. The lignin content of the shells was found to be unusually high, and the possibility of developing valuable products from this is being investigated.

In connection with investigations on the manufacture of cucumber pickles under climatic conditions prevailing in the South, it was found that soft pickles contain less pectin than the firm ones. It appears, therefore, that softening of pickles (a cause of serious loss in this industry) is caused by a change in or loss of pectic constituents. Experiments are now in progress to determine the various pectic substances, such as protopectin, pectin, and pectic acid in pickles in order to ascertain the various transformations of the pectic substances that take place, with resultant formation of soft pickles.

USE OF SWEETPOTATOES AS FEED

Shortage of winter food is frequently a limiting factor in increasing the supply of dairy products. This is of particular importance now, especially in the South, where thousands of soldiers are quartered in areas having inadequate dairy supplies for even the normal population. The present heavy load on transportation facilities of all kinds makes it increasingly difficult to move an adequate supply of feeds from one area to another. It is believed that this shortage can be greatly relieved by silages made from local green material. In the South, the most logical product for this purpose seems to be the sweetpotato, including vines, since it is produced in high yields throughout this area.

In cooperation with the Mississippi Agricultural Experiment Station, microbiological studies were made on the production of silage from cull sweetpotatoes and sweetpotato vines. The results of bacteriological tests, chemical analyses, and feeding tests, obtained thus far on 10 experimental lots of silage prepared in various ways, indicate that sweetpotato culls and vines, through ensilage, may become a valuable supplement to other materials for winter feeding. Further experiments are needed to work out the optimum conditions for preparing silage from sweetpotato vines and culls, separately and blended with other agricultural products.

This type of work will be continued during the coming season at the Bureau's field station at Raleigh, N. C., in cooperation with the North Carolina Agricultural Experiment Station. The bacteriological and chemical changes that take place during fermentation and storage of this type of silage will be studied, and feeding tests will be made. Important phases of the investigation will be a study of the vitamin A content of sweetpotato vines and sweetpotatoes and the development of methods of control in silage fermentation that will permit maximum retention of this valuable constituent in the feed.

In addition to the use of succulent feeds for dairy cattle, the use of dry feeds for beef cattle and other livestock is important. The South has an abundant quantity of feeds relatively rich in oil and protein, such as cottonseed meal and peanut meal, but it is almost entirely dependent on corn to furnish the carbohydrate in cattle feeding. The average yield of corn per acre here is low, and the cost is relatively high. Transportation expense is involved in bringing corn in from other areas, hence, the corn constituent of cattle rations is usually deficient.

It has been demonstrated in the past 2 years that as much as 2 tons of starch per acre can be produced in the South in the form of sweetpotatoes as compared with 1.4 tons of starch per acre in the form of corn in the Middle West. Because of the low average yield of corn per acre in the South, comparison with corn grown in this area is still more favorable to sweetpotatoes. This emphasizes the fact that sweetpotatoes are substantially a cheaper source of carbohydrate than corn for animal feeding in that area. Practically all that is needed to make sweetpotatoes available for feeding throughout the year is a cheap means of drying or otherwise preserving potatoes to prevent spoilage. Work was conducted on suitable drying methods, and as a result a sweetpotato drying plant is being installed by the State of Alabama at the Atmore Prison Farm. Drying of ground sweetpotatoes for cattle feed is also being conducted this season by a commercial plant in Louisiana. During the year feeding tests with beef cattle, dairy cattle, sheep, hogs, and mules, in which sweetpotato meal (ground dried sweetpotatoes) was used as a substitute for corn, were conducted in cooperation with the Bureau by the agricultural experiment stations of Tennessee, Alabama, and Georgia (including the Coastal Plain Experiment Station, at Tifton, Ga.)

OIL, FAT, AND WAX INVESTIGATIONS

The increased consumption of drying oils resulting from the expansion of industry, coupled with restricted imports of perilla and tung oils, has created an urgent need for greater domestic production of

drying oils. The estimated production of 5 million pounds of oil from each of the 1940–41 tung crops indicates that important quantities of this valuable product can be produced in the South. In furthering the development of this industry on a scientific basis, investigation has been conducted, in cooperation with the Bureau of Plant Industry, on certain phases of work. Oil content and oil quality were determined on 264 samples of tung fruit for the purpose of ascertaining the influence of soil type, fertilizer, cultivation, and planting of interspace crops on quality and yield of oil.

The accelerated drying of tung fruit has been studied. Acceleration of the rate of drying is important in order to minimize deterioration between harvesting and processing and to standardize the moisture content at a point suitable for maximum recovery of oil. The fruits fall from the trees in September and October containing about 70 percent of water. It has been customary to let them dry in the fields for several weeks, then place them in ventilated barns until January or February, when they are considered dry enough for milling. It has been found that the moisture content of tung fruit lying on the ground decreases from about 70 to 30 percent in 14 days, but further drying is very slow. The hulling and pressing operations are not satisfactory if the moisture content is not properly adjusted. Laboratory studies of the moisture characteristics of tung fruit and the effect of various drying temperatures on the yield and quality of tung oil indicated that temperatures of 100° to 130° C. are suitable. Cooperative experiments conducted with manufacturers of drying equipment showed that moisture can be reduced from 30 to 10 percent in 2½ hours at 130° and that a tray or endless-belt type of dryer is more suitable for drying tung fruit than a rotary kiln drier. Cooperative drying experiments were also conducted with tung producers and millers. In these experiments heated and unheated air was blown through tung fruit stored in ventilated bins. Heated air (66°) passed upward through tung fruit reduced the moisture content from 24 to 16 percent in 24 hours. Rapid methods of determining moisture in tung fruit were developed and are now in use in tung mills for controlling operation.

Expeller presses used for expressing oil from tung kernels leave 5 percent or more of the oil in the press cake. Laboratory and pilot-plant solvent-extraction experiments were continued, since this process offers a means of obtaining practically all the oil. Thirty different solvents have been studied in the laboratory in a type of laboratory extractor that operates in the same way as the pilot-plant batch extractor. A mixed hexane-petroleum fraction gave oil of higher quality than the heptane fraction previously used. This result was verified in cooperation with a tung-oil mill in a pilot plant at Picayune, Miss. Installation of a plate-and-frame filter between the extractor and evaporator of the pilot plant resulted in the extraction of a lighter colored oil from both press cake and ground kernels. The possibility of using continuous solvent-extraction equipment is being investigated.

In cooperation with the Florida Agricultural Experiment Station, solvent-extracted tung meal was found to be nontoxic to chicks 1 week old, thus opening up a possibility of using such meal for feed (expeller meal produces toxic effects). Experiments were made on the

purification of the proteins of tung press cake for use in plastics. It has been found that tung hulls contain tannins and the shells contain lignin. Investigations were started to determine the possibilities of the commercial recovery of tannin from the hulls and the use of the shells for production of carbon for gas masks.

Domestic production of flaxseed, from which linseed oil is crushed, amounted to 31 million bushels in 1940, and the 1941 crop is expected to yield 32 million bushels, as compared with a 10-year average (1930–39) of 11 million bushels. In view of the increased domestic production of flax, the completion of an investigation of the composition of linseed oils expressed from known varieties of flaxseed grown in North Dakota, Texas, and California is of value to this growing industry. This study shows the effect of climatic conditions on the constituents of the oil, especially those constituents responsible for its drying properties. The quantities of linoleic and linolenic acids in the complex glycerides comprising the oil varied widely in oils from the same variety, grown in different localities. The linoleic acid content ranged from 9 to 23 percent and the linolenic acid content from 28 to 61 percent. These data, together with information obtained by the Bureau of Plant Industry on the plant characteristics, afford a basis for selection of flax varieties suitable for different areas and climates.

Aleurites trisperma, a tropical relative of the tung tree, was planted in various parts of Puerto Rico many years ago. In cooperation with the Puerto Rico Experiment Station, samples of seed collected from various parts of the island were analyzed for oil, and the chemical characteristics of the oils expressed from each sample of seeds were determined. The drying properties of this oil, which is known as soft lumbang oil, are dependent on the eleostearic acid content. This examination indicated that the eleostearic acid content of these oils ranged from 40 to 45 percent.

The following new oils were examined because they represent potential supplements to the domestic supply of oils and because they may contain some unique constituent of unusual value. Boysenberry seed, a byproduct of jelly manufacture, was found to contain 14.4 percent of a strong drying oil having a saponification value of 188.5 and an iodine value of 171.5. The oil content of the seed is too low to justify recovery of the oil from the limited quantity of seed now available. Seeds of the Colombian tree, *Lecythis elliptica*, were found to contain 64.4 percent of kernels that contain 57.6 percent of oil having a saponification value of 189.5, an iodine value of 114.4, and a thiocyanogen value of 73.7. This semidrying oil could be used for food purposes and for making soap if commercial production could be achieved economically. The seed kernels of *Simaruba glauca*, grown in Honduras, contained 61.5 per cent of oil having a saponification value of 190.2 and an iodine value of 54.2.

Because of the present serious shortage of waxes in the United States for production of a great variety of necessary articles, attention was directed to the possibility of obtaining suitable waxes from new sources. A wax from the leaves of the saw palmetto palm (*Serenoa serrulata*) collected by the Bureau of Plant Industry in Florida was examined with regard to its characteristics and chemical composition in relation to possible uses. It melts at 82° C., has

a saponification value of 111.4 and an acid value of 10.1, and contains about 40 percent of unsaponifiable constituents. Identification of the acidic and unsaponifiable constituents is in progress.

PROTEINS OF AGRICULTURAL FOOD PRODUCTS

EFFECTS OF STORAGE ON PROTEINS OF CORN AND SOYBEANS

The results of chemical studies on the changes in the proteins of wheat and its milled products during 2 years of storage under various controlled conditions were summarized in the annual report for 1940. Some information was also given in that report regarding the changes that had taken place within 1 year in shelled corn and soybeans and their meals, which were being used in similar 2-year storage experiments. The storage experiments with corn and soybeans and their meals have now been completed. Three types of chemical changes occurred in the proteins of all the materials studied. These were: (1) A decrease in solubility of the proteins; (2) a breaking down of the original true proteins into molecular fragments; and (3) a decrease in digestibility of the proteins as determined by treatment with pepsin and trypsin in laboratory glassware.

A decrease of 59 percent in the solubility (in salt solution) of the proteins of corn meal and of 29 percent in digestibility occurred after storage in bags for 2 years at 76° F. In the shelled corn the decreases, although significant, were not so great as those in the corn meal. The changes in samples stored at 30° were of the same type as those in similar samples stored at 76°, but were less extensive. During the first 6 months of storage the changes were more rapid than during the later periods. Feeding tests with albino rats at intervals during the storage period showed a loss in nutritive value of the proteins of corn meal and shelled corn during the first year, but practically no additional loss during the second year. During the first 6 months of storage at 76° corn meal in bags suffered a loss of 18 percent in the nutritive value of its protein, which increased to 36 percent by the end of the first year. Feeding tests also indicated a loss in the nutritive value of the proteins of shelled corn during storage, but the loss was somewhat less than that of corn meal.

The chemical changes that occurred in the proteins of soybeans and soybean meal during storage were of the same types as those in corn and corn meal, but they were less extensive and developed at a much slower rate. As with corn and corn meal, feeding tests with the soybeans and soybean meal also showed that definite losses in the nutritive value of the proteins occurred during storage.

The fact that marked chemical changes, accompanied by loss in nutritive value, occur in the proteins of wheat, corn, and soybeans, and their milled products when small samples of the whole and ground commodities are stored under controlled conditions in the laboratory, suggests that similar and even more extensive changes may occur in grain, flour, and meal that is being stored in large quantities under less favorable conditions. Such changes are of practical importance in animal feeding and human nutrition. To minimize them, the whole grains and seeds, rather than their milled products, should be stored; the containers and conditions of storage should be such as retard deteriorative changes; and the storage period

should not be any longer than necessary. Partly to offset deterioration in the nutritive value of the proteins of stored grains or meals, fresh grains or meals may be mixed with stored materials of the same kinds at the time of consumption.

SELENIUM-CONTAINING AMINO ACID

The annual report for 1940 mentioned the isolation from *Astragalus pectinatus*, a species of vetch that thrives on seleniferous soils, of a crystalline organic nitrogenous substance that resembled an amino acid but contained selenium and sulfur. Analyses indicated that the crystals consisted of a mixture of two isomorphous amino acids, one containing selenium and the other containing sulfur, in the ratio of 2 to 1, respectively. During the past year several new preparations of the selenium-sulfur-containing nitrogenous substance were obtained from a new supply of the seleniferous plant. The behavior, properties, and composition of these preparations were the same as those of the preparation obtained from the first lot. Two difficultly soluble crystalline compounds were also isolated; these are believed to represent the individual isomorphous components of the crystals of the selenium-sulfur-containing nitrogenous substance. Larger quantities of these two compounds are being isolated for closer study. It appears that the selenium-containing amino acid exists in the plant in uncombined form.

The results of the work with *Astragalus* indicate the type of selenium-containing amino acid in the gluten of seleniferous wheat and suggest the method for its isolation. There are a number of points of similarity between the properties of the selenium compound isolated from *Astragalus* and those of the selenium compound in the leucine fraction isolated from the hydrolysate of the wheat gluten.

LANTHIONINE, A NEW AMINO ACID

A new sulfur-containing amino acid was isolated from the acid hydrolysate of wool that had been boiled for 1 hour with a 2-percent solution of sodium carbonate. This was proved to be a symmetrical thioether amino acid and was named "lanthionine" because of its source. It differs from the well-known amino acid, cystine, by having one less sulfur atom in the molecule. It also differs from the thioether amino acid previously reported to have been isolated from wool by a foreign chemist. By following the same procedure used for its original isolation from wool, lanthionine was also isolated from human hair, chicken feathers, and milk albumin.

Lanthionine appears to be the same type of sulfur-containing amino acid that is associated with the selenium-containing organic compound in seleniferous plants. It is the first symmetrical thioether amino acid isolated from a protein. The relationship between the structure of lanthionine and those of cystine and methionine is of interest in connection with questions of sulfur metabolism in the body and the structure of proteins. Feeding experiments are in progress to learn if lanthionine has special significance in animal nutrition.

DIGESTIBILITY OF SOYBEAN PROTEINS

In order to throw more light on the question why, in animal feeding, the proteins in raw soybean meal are not utilized as fully as when

the meal is cooked, studies were made on the digestibility of soybean protein, raw and cooked. After treatment with the enzyme trypsin, it was found that the undigested residue of raw protein contained more of the total cystine of the original soybean protein than did the corresponding undigested residue of cooked protein. Larger proportions of the amino acids arginine, histidine, and lysine were also retained in the undigested residue of raw protein. It appears, therefore, that soybean protein is more difficultly digestible when raw than when cooked and that several of the nutritionally important amino acids are retained in the undigested residue of protein in forms that cannot be assimilated. This would explain why, in actual feeding tests, the addition of cystine improves the nutritive value of raw soybean meal, even though chemical analysis shows enough cystine is present. It was also found that cystine is not liberated readily when raw soybean meal is subjected to acid hydrolysis. Only after boiling the meal for 36 hours with 20-percent hydrochloric acid was all the cystine liberated from the protein. The cystine of most proteins is completely liberated within 24 hours or less when subjected to similar acid hydrolysis.

AMINO ACIDS IN EGGS

The amino acids in fresh hens' eggs were determined by methods previously developed by the Bureau and used in studying the amino acid content of grains and their milled products. The eggs were from lots of hens fed different diets of known composition in experiments being conducted by the Animal Nutrition Division of the Bureau of Animal Industry. Results obtained thus far indicate that even when hens of the same breed are fed identical rations, the quantities of individual amino acids in the proteins of eggs from different hens vary considerably. However, eggs from hens fed a high-protein ration show a tendency toward higher cystine and arginine contents than eggs from the same hens when fed a low-protein ration.

CHEMISTRY OF ENZYMES

Work on the chemistry of enzymes as a regular fundamental research project under agricultural chemical investigations was supplemented by studies on enzyme action at low temperatures as a Bankhead-Jones project.

The report for 1940 discussed the results of a preliminary study of the enzyme-activating substance that the Bureau had discovered in the petroleum-ether extract of unbleached wheat flour. It was a proteinlike substance containing sulfur, but differed from the known proteins in its chemical properties. It was believed to be an example of the lipoproteins, the chemistry of which group was still unknown. A large quantity of this substance was extracted from 10 barrels of unbleached wheat flour with gasoline and used in further research on its chemical constitution and properties. It consists of a fatlike body combined with a polypeptide base. The polypeptide was separated, purified and crystallized as the hydrochloride. The basic portion of the crystalline compound consists largely, if not entirely, of amino acids, the most abundant of which are arginine and cystine. It is very basic and has the properties of an oxidation-

reduction system, resembling glutathione in this respect. In its oxidized form, the sulfur is present as cystine, and in its reduced form, as cysteine.

The new crystalline nitrogenous and sulfur-containing organic compound isolated from the gasoline-soluble substance in wheat flour was found to have a germicidal effect on certain types of microorganisms, generally those that produce catalase. It also appears to be capable of influencing the functioning of animal organs.

Substances similar to the enzyme activator extracted from wheat flour with gasoline have been found in wheat germ, wheat bran, oats, and alfalfa, but so far no attempt has been made to investigate them closely. It appears that organic material of this type is rather common in plants. The substance extracted from fresh wheat flour was also found in rancid flour.

From studies on the enzyme systems in wheat, it appeared probable that the ripening of green wheat could be accelerated by exposure to air containing ethylene gas. Such treatment, if successful, would be especially useful for combine-harvested wheat, which frequently is not fully ripe when cut and therefore has to go through a "sweating" period before being suitable for milling. Sometimes excessive heating during the sweating period necessitates extra handling. A preliminary experiment on a small scale showed that treatment of rather green wheat with ethylene gas actually did cause rapid ripening, as evidenced by improved baking quality of the freshly made flour and a shorter period of dormancy before the seeds would germinate. The carbon dioxide formed during the process of ripening apparently had no bad effect on the viability or quality of the wheat. Flour having normal baking properties could be made from the treated wheat after 3 days, whereas flour of equal quality could be made from untreated wheat from the same lot only after about 5 weeks. A large-scale experiment in Kansas showed that treatment of rather moist wheat with ethylene gas prevented the grain from heating for at least 10 days. Within that time the untreated wheat of the same lot in another bin, used for comparison, heated to such an extent that it had to be moved.

In cooperation with the Puerto Rico Agricultural Experiment Station, which is trying to promote the culture of vanilla beans to replace overproduced coffee, further study was made of the role of enzymes in the processing of vanilla beans. It was found that freezing the beans before submitting them to the usual curing process improved the appearance and quality of the cured beans. For use in determining the vanillin content of fresh beans and of beans cured during the previous year, a quick and satisfactory new method for vanillin determination was developed and published. By this method it was found that vanillin does not exist in significant quantities in the fresh beans but is developed by enzyme action during the curing process. To ascertain the nature of the reactions taking place, the course of this development is being studied under various conditions.

A search was made for a domestic source of plant proteinase to supplement or replace the imported Indian papain that is obtained with difficulty at present because war has disrupted world commerce. Pumpkins, squash, cantaloups, honeydew melons, and figs were studied because they contain such enzymes. However, the quantities found

were too small to be of practical importance, except possibly that in figs. Further studies were to be made on the 1941 crop of figs.

An attempt was made to prevent the usual rapid deterioration of wheat germ, a food product rich in vitamins, by storing it in carbon dioxide. A distinct decrease in the rate of deterioration was noted, but the material did not keep perfectly.

ENZYME ACTION AT LOW TEMPERATURES

A detailed study was made of the break-down of connective tissue in beef through enzyme action, which has a tenderizing effect on the meat. The enzyme, which exists in intramuscular connective tissue and is responsible for its gradual break-down, is even present in the tendons, but its effect on tendons in the fresh beef carcass was found to be very slight. This enzyme, which has been isolated from beef tendon, concentrated, and somewhat purified, was found to be either identical with, or very similar to, the protein-digesting enzyme previously isolated from beef muscle and identified as a cathepsin.

Another enzyme was found in beef muscle. This is incapable of attacking proteins but breaks down peptides of low molecular weight, such as result from hydrolysis of beef proteins. This peptide-splitting enzyme, or muscle peptidase, has been isolated from beef muscle and purified. Studies on the purified material showed that it attacks only peptides beginning with the amino acid leucine, and is therefore a leucyl peptidase. It is activated by manganese compounds. It is active only under slightly alkaline conditions and therefore is apparently incapable of producing any change in stored beef until the pH value has been raised by other autolytic reactions resulting in the liberation of ammonia. The function of this enzyme is evidently to complete the protein hydrolysis started by the protein-digesting enzyme previously mentioned. Obviously it is active in the last stages of decomposition when meat is no longer fit for food purposes. Since the body fluids are more alkaline than muscle tissue, it is possible that in living animals this enzyme is active in blood or lymph.

The action of plant proteinases when added to meat in the form of commercial meat tenderizers was found to be very slow at room temperatures but rapid at cooking temperatures. Practically all the effect of commercial meat tenderizers occurs during cooking. The added enzyme does not penetrate the muscle; it affects only the outside. There is a marked difference between the effects of applying a plant proteinase to the surface of meat and the natural tenderizing produced by the enzymes existing within the meat tissues. The best solution of the problem of making fresh meat tender still seems to be the utilization, with proper control, of these inherent catalysts of decomposition.

Further attention was given to the old question of whether the freezing of meat and other agricultural products makes them decay more quickly after being thawed. One great difficulty in the study of this question, as it applies to meat, has been the lack of a wholly satisfactory criterion of spoilage. On the basis of the production of nonprotein tyrosine and its measurement by colorimetric methods, the best criterion now available, considerably more decomposition at room temperature occurred in liver that had been frozen than in liver that had been kept chilled but unfrozen for the same length of time. Freezing of beef muscle, pork muscle, and chicken muscle did not

increase the rate of decomposition after thawing, as shown by experiments similar to those with liver. Brain tissue showed a slight increase in rate of decomposition after being frozen. Apparently there is a difference between muscular tissue and glandular tissue with respect to the rate of decomposition after being frozen and subsequently thawed. This observation is important in the freezing storage of dressed chickens and other small carcasses because the liver and other glands frequently left in the carcass might decompose rapidly after thawing and adversely affect the quality of the whole carcass.

Considerable useful information resulted from the further study of the plant proteinases bromelin and papain, obtained from pineapple and papaya, respectively, in connection with their preparation for use in the experiments with meat. A new crystalline proteinase has been isolated from papaya latex. This has been named "chymopapain." Publications concerning bromelin and papain and their preparation have aroused much interest in the meat and chemical industries. The process for making an improved papain product, which was mentioned in the report for 1940, has been turned over to the Western Regional Research Laboratory for pilot-plant study.

Further studies on the esterase previously found in muscular tissue led to the belief that it is not involved in either oxidation or spoilage of fats during cold storage of meats. It was reported last year that this esterase hydrolyzed only the lower members of the methyl and ethyl ester series, and did not attack any of the true fats. Its function in muscular tissue still remains unknown.

A report that butyl tyrosine inhibits the enzymic decomposition of fats when added in small quantities was verified. Trials with other materials indicated that ethyl isoferulate has about two-thirds as much stabilizing effect as butyl tyrosine. The former compound is a byproduct of orange-juice packing. Its ability to retard decomposition of fats may be of interest to the citrus-products industry.

Storage of fat in an atmosphere of carbon dioxide was found to retard rancidity, but only when the air was entirely replaced. This process might be useful for keeping edible oils sweet in sealed cans. Tests were made with the lipoprotein isolated from wheat flour to see whether corn oil could be stabilized by the addition of such material. Instead of acting as a fat preservative, it appeared to be a definite catalyst of rancidity.

Because there is reason to believe that the preservation of fat in smoked meat results from some enzyme-inhibiting constituent of the smoke, a study was begun on the penetration of smoke into meat. The results obtained so far cannot be expressed quantitatively. It was learned, however, that penetration of meat by smoke is very slight with modern methods of smoking. A striking break-down occurred in both the fat and the protein of pork during smoking and also during the preparatory pickling or curing process. Although this break-down was an extensive autolysis, it was not accompanied by the objectionable features that characterize spoilage.

CHEMISTRY OF MISCELLANEOUS PLANT CONSTITUENTS

Attention was given to the natural minor constituents of edible seed oils that retard or prevent rancidity when the oils are exposed to air or other oxygen-containing substances. These constituents,

called antioxidants, are largely removed or destroyed in the refining of edible oils. Fuller knowledge concerning them might suggest means for preventing their loss during refining processes or of offsetting their loss by addition of other antioxidants of similar composition. Particular attention was directed to cottonseed oil, as a typical edible oil that develops rancidity. The work on cottonseed oil was done in cooperation with the National Cottonseed Products Association, which supported a research fellow in the Bureau's Washington laboratories.

In order to learn more about the constituents of cottonseed oil, including natural antioxidants, an alkali-refined cottonseed oil was separated into many fractions by vacuum distillation in a short-path or so-called molecular still. The unsaponifiable material, which includes sterols and some pigments, was effectively concentrated in the first or most volatile fraction, representing about 6 percent of the original oil. Each of the fractions was subjected to accelerated oxidation tests to determine its stability or keeping quality. The first fraction was the most stable, indicating that it contained most of the antioxidants. When some of this first fraction was added to other fractions their stability was increased.

In addition to molecular distillation as a first step in concentrating the antioxidants or inhibitols, extraction with solvents was tried, with some success. A potent inhibitol fraction extracted from crude cottonseed oil with 95-percent ethanol was concentrated by subsequent crystallization of the inactive portion of the extracted material from acetone at −65° C. and by a solvent-partition procedure applied to the acetone-soluble fraction. A small quantity of a substance having high antioxidant activity was obtained by this method.

Another approach to the problem of isolating the antioxidants was to convert the glyceride components of the oil into their methyl esters by direct interchange of the respective alcohol groups, using sodium methylate as a catalyst. This conversion was accomplished under mild treatment in order to cause little or no deterioration of the natural antioxidants. Because the methyl esters are much more volatile than the glycerides it was possible to remove them by distillation, leaving a small residue, which consisted chiefly of the antioxidants, sterols, pigments, and other minor constituents. These groups of constituents were separated from each other by a combination of crystallization and solvent-extraction methods.

A comparison was made of the antioxidant content of crude, alkali-refined, and steam-deodorized cottonseed oils. It was shown definitely that crude cottonseed oil contains an effective antioxidant that is not present in detectable quantities in alkali-refined and steam-deodorized oil. The identity or chemical structure of this antioxidant has not yet been established. Inhibitols, such as tocopherols, were present in all the cottonseed oils examined.

Cottonseed oil was separated by low-temperature crystallization from acetone into seven fractions varying with regard to the average degree of unsaturation of the fatty acids in their complex glycerides. The iodine numbers ranged from 52.5 to 148.3. The acids of the fraction having the lowest degree of unsaturation were 35.6 percent unsaturated and 64.4 percent saturated. Those of the fraction having the highest degree of unsaturation were 92.3 percent unsaturated

and 7.7 percent saturated. The fraction containing the highest proportion of unsaturated acids represented only a small percentage of the original oil. The method used for fractionating the oil has possibilities as a step in the isolation of particular glycerides.

In connection with an investigation on the glycerides and other constituents of perilla oil, a study was made of the thiocyanogen absorption by methyl linolenate in comparison with such absorption by methyl oleate and methyl linoleate. The results led to material improvement of the method for determining thiocyanogen values of fats and oils, which are essential for estimating the composition of mixtures containing more than two unsaturated acids. Such estimates have a practical application in the grading of food oils on the basis of composition of their fatty acids, since the composition influences stability during storage and certain uses.

Studies were conducted on certain constituents of sweetpotato vines because of their possible use for cattle feeding, particularly in the southern States. The vines are readily eaten by cattle. They are high in protein and their nutritive value should be close to that of alfalfa and clover. The leaves of sweetpotato vines, after being dried, were found to contain from 291 to 477 parts per million of carotene, the precursor of vitamin A. The leaves contained more carotene than the leaf stems and the latter contained more than the vines. An unexpected and important observation was that the carotene in sweetpotato vines, stems, and leaves is unusually stable during drying and storage of the material. In alfalfa hay there is considerable loss of carotene during drying and storage. Sweetpotato vines were examined for substances that might be detrimental to cattle, but no alkaloids, cyanogenetic glucosides, saponins, toxic resins, or other substances that might have injurious effects, were found. Feeding tests with sweetpotato vines are being made by cooperators. A contemplated use for sweetpotato vines is for cattle feeding in the Florida Everglades, where the beef cattle industry has assumed increased importance in recent years and where there is a deficiency of local feed. Tests by cooperators have shown that enormous yields of sweetpotato vines may be obtained in the Everglades.

In view of the possibility of growing licorice root as an agricultural crop in the United States or nearby Latin American countries, efforts were made to develop practical methods for extracting and purifying its sweet constituent, a glucoside known chemically as glycyrrhizin. This substance is about 200 times as sweet as ordinary sugar and would be useful as a safe sweetening agent in the food of several million people whose diet is restricted in sugar because of overweight, diabetes, or diabetic tendency. Sixty to seventy million pounds of licorice root have been imported yearly in the past, but the present supply is limited, and imports may soon be discontinued. About 80 percent is used by the tobacco industry; the rest is used in confectionery and medicinal preparations.

MICROBIOLOGY OF FOOD PRODUCTS

Cooperative studies were made on microbiological problems connected with the chemical and technological research on production of sugar and the preservation and use of fruits and vegetables. The results of some of this work are reported briefly under the various

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commodities discussed in this section of the report. All the microbiological studies during the past year have had immediate practical applications as their objectives.

One of the objectives in the production of sugar is the elimination of traces of nonsugar substances that sustain the growth of yeast and other micro-organisms in solutions of the sugar. The presence of yeast-stimulating substances in sugar is objectionable, for instance, in the manufacture of bottled beverages because it might result in a visible crop of yeast that would cloud the beverage and make it unsalable. Studies are in progress on the identification of these substances. A knowledge of their identity would aid in devising means for their elimination.

Encouraging results were obtained in experiments on the use of specially selected yeasts for eliminating the invert sugar from sorgo juices and sirups by fermentation before crystallizing the sucrose. Invert sugar is a natural constituent of sorgo cane, and its presence is an advantage when sirup alone is the desired product. In the production of sugar, however, if the quantity exceeds a certain proportion of the total sugars present it interferes with crystallization of the sucrose. The results of the experiments indicate that certain yeasts will eliminate or greatly reduce the invert sugar by fermentation without any loss of sucrose.

In order to obtain information of practical importance in the freezing preservation of fruits, studies were made on the influence of different concentrations of sucrose in loganberry juice on yeast cell behavior at 0° F. and on the microbial behavior in buffered water and in buffered 30-percent sucrose, dextrose, and invert sugar sirups stored at 0°. The results of these two studies demonstrated that different concentrations of sucrose and different sugars of the same concentration exert different influences on microbial behavior at 0°. Since sucrose offers some protection to micro-organisms at this temperature, it might be advantageous to reduce the quantity of sucrose to the minimum consistent with the maintenance of good quality and change the processing technique so that the sucrose is distributed uniformly throughout the frozen product.

PHARMACOLOGY OF POSSIBLE FOOD CONTAMINANTS

Research on the pharmacology of possible food contaminants was continued in cooperation with Stanford University Medical School at San Francisco, Calif. Much of the work was concerned with the possible acute or chronic toxicity of organic chemical substances recently proposed for use as insecticides or fungicides in the belief that they are less dangerous than arsenicals and other inorganic compounds toxic to animals. The need for the protection of food plants against insects has led to a continuous search for new insecticides having advantages over the older types in ease of application, more effective killing, and less danger to public health. As these new types of insecticides were made available, it became evident that toxicity determinations were necessary to protect the public health.

The work of the Bureau has shown on the one hand the danger of using certain compounds and on the other the usefulness of certain others. For example, two more papers, the ninth and tenth of a series, were published on phenothiazine, a sulfur-containing

organic compound proposed by the Department of Agriculture in 1935 for use as an insecticide. This substance was tested by this Bureau for toxicity to animals and was incidentally found to have therapeutic value as a urinary antiseptic. Later it was found to have value for removal of intestinal parasites from farm animals, especially sheep, and still later it was found to have value as a fungicide.

One of the two papers published during the year dealt with the atmospheric oxidation of phenothiazine, an insecticide, to phenothiazone, a fungicide. The other dealt with the anthelmintic action of thionol, which is produced by oxidation of phenothiazine within the animal body.

It was reported last year that the Bureau had discovered that an apparent carcinogenic or cancer-producing effect is produced by a proposed insecticide, 2-acetamino fluorene, when fed to albino rats. Sufficient experimental evidence has now been accumulated to prove that this compound actually has a carcinogenic action. It has one of the simplest molecular structures of known carcinogenic compounds and is exceptional in that it can induce neoplastic changes in many organs, often in the same animal. It has produced carcinomas of the bladder, cutaneous or subcutaneous epidermoid carcinomas, subcutaneous adenocarcinomas, primary carcinomas of the liver, myogenic sarcoma, and carcinomas of the ureter, renal pelvis, colon, pancreas, and lung. A detailed report on the results of this study has been prepared for publication. The discovery of the carcinogenic activity of this proposed insecticide is important from both a practical and a scientific standpoint. If the compound had been released for public use without pharmacological investigation, the consequences might have been very serious to persons engaged in manufacturing, handling, and using this insecticide. The discovery is also a contribution to the fundamental knowledge of cancer.

Some additional work was done on the chronic toxicity of the compounds of cadmium, a metal that has come into rather extensive use in recent years as a rustproof coating for iron and steel and that might contaminate food on contact. A study of the toxic action of cadmium as the result of long-continued feeding of a diet containing a cadmium compound was completed, and a paper reporting the results of the study was published. The manifestations of chronic cadmium poisoning in albino rats are severe anemia, cardiac hypertrophy, and a bleaching of tooth enamel similar to, if not identical with, that produced by fluorine compounds. This type of work takes on added importance in the present national emergency, when the search for substitutes for strategic materials is leading to the use of protective coatings in many fields, including the food industry. The results of the Bureau's work point to the necessity of the complete testing of new compounds before introducing them into industries that have a bearing on the public health.

Except in the preparation of some manuscripts for publication, the work on derris, rotenone, diphenylamine, phenazine, azobenzene, pentaerythrityl bromide, and dinitro-orthocresol acetate has been practically completed. Work on 2-acetaminofluorene, fluorene, fluorenone, fluorylamine, and xanthone is still in progress.

The disruption of our foreign trade has brought a shortage of certain essential drugs and drug constituents, and there is danger of com-

plete stoppage of some of these valuable imports. Accordingly, the Bureau has begun research on the development and pharmacological testing of essential drugs of domestic origin that might be used to replace imported products that cease to be available.

EFFECTS OF INDUSTRIAL CONTAMINANTS ON THE COMPOSITION OF PLANTS

The increasing tendency of industry to locate manufacturing works in the country to be near the source of supplies has increased the hazards to plant life in the byproduct wastes that these smelters and factories pour into the air, into the streams, and on the soil. Crops and other plants injured by the harmful gases may be discolored or simply unthrifty, stunted, and unproductive. The economic welfare of the farmer may be threatened, but there is no deposit of soot or dust or other tangible material that will enable him to demonstrate his belief that the air is contaminated. To do this he needs scientific assistance. The Bureau's fundamental studies of the effects of industrial contaminants on the chemical and physical composition of plants are expected to furnish information that will assist the farmer in handling this problem.

Investigation of the effects of industrial contaminants was started by building and assembling apparatus needed in determining the action of gases and fumes on the physical and chemical composition of plants. Because of its highly toxic action on plants and also because of its prime importance as an industrial effluent, sulfur dioxide was selected as the first gaseous agent to be studied. The apparatus, therefore, has been adapted and calibrated to the particular properties of this gas, but it is suitable for subsequent employment with other compounds. Two fumigating outfits have been built, one for inside use for treating potted greenhouse plants, and another and larger one for fumigating plants in outside field plots, where space is not restricted. This latter equipment provides for the treatment of plants up to 9 feet in height. With both fumigating outfits, growing plants are treated under closely controlled environmental conditions simulating those in regions exposed to gases and fumes from smelters and factories. The apparatus, which provides for simultaneous experimentation with test and control plants, is electrically operated and largely automatic, and gaseous concentrations are maintained for indefinite periods at any desired level.

The fundamental process of living plants is that in which food materials are synthesized from atmospheric carbon dioxide and soil water. In this process the energy obtained from the sunlight is made available as chemical energy in the leaves, with the production of the varied and complex carbohydrates including starch and the sugars. The green matter or chlorophyll of the leaves has an essential role as a transformer of a portion of the light energy needed for the translation of the carbonic acid to carbohydrate. Thus, it is evident that an injury to the chlorophyll or an impairment of its function directly interferes with vital plant processes such as those of assimilation and respiration. Sulfur dioxide has an extremely detrimental action on chlorophyll, and this action now is being studied. Reactions affecting the proteins and their storage also are under consideration, and fumigated and untreated plant tissue is being collected for subsequent study of these nitrogenous compounds along

with the carbohydrates. Other chemical problems pertinent to the investigation include a study of possible aldehyde reactions, of effects on the pH value of the plant juices, and of the absorption of abnormal quantities of sulfur through the leaf stomata.

Another important aspect of the industrial contaminant investigations is that relating to microscopic studies. In the exposure of plants to contaminated atmospheres, stomate behavior of the leaves is an important and sometimes controlling consideration. Studies now in progress are revealing pronounced abnormal leaf behavior in the presence of comparatively low sulfur dioxide concentrations. To insure other than a temporary record of these observations and measurements, a technique has been developed whereby histological procedure slides of representative specimens may be preserved for some time with a view to obtaining permanent records by means of photomicrography.

THE CHEMISTRY OF WEED ERADICATION

In setting up the project for the study of the chemistry of weed eradication, the work was brigaded with that relating to industrial contaminants for the reason that an important factor is common to the two studies, that is, determination of the effects of toxic chemical agents on the physical and chemical composition of the plants. This view is based on the obvious consideration that, in many aspects of the problems to be investigated, it is immaterial whether the immediate purpose is to destroy the plant at hand or to obtain information useful in protecting similar plant structures.

In the growth of plants, organic components are elaborated from the soil and air. Some of the components are subject to immediate alteration in the processes of life and growth, and some are translocated from one part of a plant to another, where quantities exceeding current needs are stored as food reserves. Among these reserves, which account for the recuperative capacity of certain important noxious weeds, there are numerous compounds, but many of the better known individuals are commonly grouped into two great classes, those containing nitrogen, such as the proteins and, secondly, the varied and complex carbohydrate compounds. Ordinarily, in their growth, plants do not accumulate proteins in vast excess of immediate needs, but the carbohydrates, notably the sugars and starches, are present in large quantities. It is believed that included in these reserve compounds, as well as among those of a transitory and intermediate character, there may be individual chemical compounds peculiarly susceptible to adverse effects by toxic chemical agents. In the current studies, an attempt is being made to obtain any information possible as to the identity of these key substances and of their fate under chemical treatment and to develop the simplest type of analysis possible, as applied to proteins and carbohydrates, which will determine the ability of the plant to recuperate after chemical treatment. The chemical treatments and subsequent tests are accompanied and supplemented by microscopic examinations that reveal the action on leaf stomata, the shrinkage of cell walls, and other histological effects.

In the present studies weeds were treated with sulfur dioxide, one of the chemical agents most destructive to plant life. Preliminary

results indicate that this compound, in comparatively low concentration, is lethally effective in contact with certain species of annual weeds, for example, charlock or wild mustard. The information developed is sufficiently promising to encourage further work with other gases and fumes in a field of herbicidal investigation which, heretofore, has received little attention.

INDUSTRIAL UTILIZATION OF FARM PRODUCTS AND BYPRODUCTS

The work on industrial utilization of farm byproducts carried on at the Agricultural Byproducts Laboratory, at Ames, Iowa, in collaboration with the Engineering Experiment Station of Iowa State College, was limited during the past fiscal year to crop wastes. At the beginning of the year, the regional research laboratories took over most of the work of the former Industrial Farm Products Research Division, including that of the Agricultural Byproducts Laboratory. The work on crop wastes was carried on under the supervision of the Agricultural Residues Division of the Northern Regional Research Laboratory.

Further attention was given to the possibilities of using crop wastes for the production of low-cost plastics, pulp for paper manufacture, and lignin complexes for purifying water for industrial uses.

Preliminary experiments on the suitability of various crop wastes (corn stover, corncobs, cereal straws, flax shives, tobacco stems, and the residue from oat hulls used for the commercial production of furfural) for making molding powders similar to those previously made from sugarcane bagasse showed, under the experimental conditions used, considerable variation in the properties of the powders made from the different materials. The residue from acid-hydrolyzed oat hulls may be a promising material for the manufacture of lignin plastics, but further studies are necessary before the commercial feasibility of plastics from any of these crop residues can be established. An automobile manufacturer who experimented with bagasse plastics prepared by the Bureau has reported that a steering wheel molded from a mixture of 80 percent of aniline-bagasse powder and 20 percent of neoprene satisfactorily passed laboratory and service tests. An article concerning plastics from bagasse and other crop residues was prepared and published in Manufacturers Record at the request of its editor.

A crude lignin complex prepared from corncobs was found to be almost as effective in removing iron from water as was the purified lignin studied previously. Elimination of the purification step would materially reduce the cost of the lignin product. Filter beds of paper pulp or sand impregnated with this crude lignin have shown relatively large iron-removing capacity without appreciable exhaustion, suggesting the possibility of their use for water purification on a large scale. The efficiency of these filters can be kept at a high level by regenerating the active surfaces with dilute mineral acid.

Further studies on pulping crop wastes with dilute nitric acid indicated that a yield of about 40 percent of well-cooked pulp may be obtained from sugarcane bagasse. However, the data obtained thus far are not sufficient to permit definite conclusions to be drawn regarding the economic value of the nitric-acid process for producing cellulose pulps from crop residues.

Work on the conductometric analysis of neutral sodium sulfite and ammoniacal pulping liquors was completed, and the results were published. This method, which is rapid and fairly accurate, facilitates fundamental investigations on the course of pulping reactions.

The results of previous microbiological work on the anaerobic decomposition of cornstalks and wheat straw show that glass and stainless-steel containers are superior to copper, galvanized-iron, and black-iron containers for this fermentation.

A final report on the production of gluconic acid and its calcium salt from dextrose by submerged mold fermentation is in course of publication. It shows that reuse of the organisms (*Aspergillus niger*) recovered by filtration and by means of a centrifuge resulted in greater economy than was obtained with the flotation method; the complete charge was recovered after each fermentation.

Part of the funds for research on industrial utilization of farm products and byproducts and the facilities of the Agricultural Byproducts Laboratory were used by the Bureau's Division of Farm Mechanical Equipment in a preliminary study of the present status of machines and methods for harvesting and baling crop residues, in which the Engineering Experiment Station of Iowa State College and the Northern Regional Research Laboratory participated. Field tests with modified experimental harvesting and baling machinery indicated that the cost of harvesting a grain crop, separating the grain, and baling the residue may be reduced by the use of suitable machines of improved design.

NAVAL STORES INVESTIGATIONS

PRODUCTION, PROCESSES, AND EQUIPMENT

A modification was made in the Bureau's previous design for a steam-heated turpentine still to permit the use of steam at 100 to 125 pounds gage pressure instead of 200 pounds, which had been generally believed to be necessary for attaining reasonable rates of distillation and proper temperature for discharging the rosin. This reduction in steam-pressure requirements permits the use of smaller boilers and reduces the cost of upkeep. A pilot-size steam turpentine still, the coil area calculated for a satisfactory rate of distillation with 100 to 125 pounds of steam, was constructed and operated satisfactorily. The data obtained from experiments wtih this still make it possible to specify the proper coil area for any desired rate of distillation of pine oleoresin with any given steam pressure between 100 and 200 pounds per square inch.

After much experimental work in the laboratory, directed toward the development of a continuous process for cleaning and distilling pine oleoresin, a pilot plant for accomplishing this objective was designed and constructed. This plant is being used to obtain experimental data required for development of the process on a commercial scale. Very encouraging results have been obtained in its operation. The crude oleoresin is fed continuously into one of the units of the assembly, and the end products—turpentine and rosin—are continuously discharged from others. Applications have been filed for several patents covering novel features of the process and apparatus, which, if granted, will be assigned to the Secretary of Agriculture.

Heretofore the processes used for cleaning and distilling pine oleoresin have been separate and intermittent, and were operated on a fixed quantity or "batch" of material. The development of a continuous commercial gum cleaning and distillation process would reduce fuel requirements materially. It would also reduce the cost of operation in other ways and contribute toward uniformity of products.

The principal cause of dark-colored rosin is contamination of the oleoresin with iron during collection or handling. Such contamination may be prevented by replacing old galvanized aprons, cups, and dip barrels with new nonferrous or properly coated equipment when they show areas of uncoated iron or steel. But when the damage has already been done through lack of suitable equipment, most of the iron contamination can be removed from the gum, prior to its distillation, by a process developed at the Naval Stores Station during the past year. The gum is diluted with turpentine, melted, and filtered (the initial steps of the regular gum-cleaning process), after which it is washed with a dilute mineral acid, such as sulfuric. Rosin from stained gum treated in this way will be much paler than rosin from the untreated gum and may differ from it by as much as six grades.

Several jet condensers of the type designed at the Naval Stores Station and described in last year's report were installed and put in operation at commercial turpentine plants with aid from representatives of the Station.

Two more commercial turpentine plants which use the batch process of gum refining developed at the Naval Stores Station started in business during the past year and will operate under a license agreement with the Secretary of Agriculture, to whom the patent on the process has been assigned.

Extensive actual service tests were continued on more than 1,000 turpentine gum cups, in which glass cups designed by the Bureau were compared with Herty clay cups and metal cups made from sheet aluminum, stainless sheet steel, tin-coated sheet iron, lead-coated sheet iron, and galvanized sheet iron. Galvanized cups which had been coated with five different kinds of paint and with shellac varnish were also included in the tests, but three of the paints and the shellac varnish peeled so badly that they were of no value. Most of the cups had been used previously for one to three seasons. In general, the rosin from gum collected in the glass cups graded as high or slightly higher than that from gum collected in aluminum cups or Herty clay cups, and much higher than that from gum collected in tinned-iron, galvanized-iron, or painted galvanized-iron cups. Rosin from gum collected in stainless-steel cups (new or used one season) graded about the same as that from aluminum cups, and that from gum collected in lead-coated cups graded the same or a little lower than that from aluminum cups. The results showed definitely that slash pine gum is less corrosive than longleaf pine gum to galvanized iron. Previous tests showed that properly designed glass cups compare favorably with clay cups as regards fire and freezing losses. The latest, as well as former, tests demonstrated that rosin from glass cups grades as high as that from aluminum cups. These advantages of glass cups, together with present restrictions on the use of

aluminum and even galvanized iron, for anything other than defense purposes, should greatly increase the demand for glass cups for collecting turpentine gum.

To show the effect of turpentine dehydration on possible coloration during storage of turpentine packed in uncoated sheet-iron containers, a number of such containers were nearly filled with portions of an acid-free and water-free turpentine, to some of which were added, alone or in certain combinations, organic acids, water, and other substances which may be present in commercial turpentines. The containers were closed tightly and allowed to stand for several months, after which the contents were examined for contamination with iron compounds. It was found that both water and a resin or other acid must be present for the iron to be attacked with formation of turpentine-soluble or water-soluble iron salts. Obviously gum and rosin acids must be excluded or removed from moist turpentine to keep it from attacking iron. Entrainment of gum and rosin particles in turpentine vapors may be avoided by improved distillation processes. Another way to keep turpentine from attacking iron would be to dehydrate it and keep it anhydrous. Turpentine can be substantially dehydrated, but at present there is no practical method for keeping turpentine anhydrous in large storage tanks.

Experiments on the storage of unconditioned turpentine in containers made of ternplate, a possible substitute for tin plate during the present national emergency, showed that the turpentine changed in color, specific gravity, and acidity due to the presence of water-soluble acids and turpentine-soluble acids.

It is believed that a substantially neutral turpentine, suitable for storage in metal containers, may be obtained by installing a trap to catch particles of gum or rosin entrained with the water and turpentine vapors, and using a jet condenser for the vapors. The large volume of water used in this type of condenser and the thoroughness with which this water, as fine spray, comes in contact with the steam and turpentine vapor from the still would wash out and carry away most of the water-soluble acids.

As in the past, a large part of the work at the Naval Stores Station was educational. Information on processes and equipment for producing turpentine and rosin and on handling practices and equipment was given to producers and other interested persons, totaling 592, who visited the Station and in reply to 252 letters. Two cooperative agents representing the States of Florida and Georgia continued to make personal contacts with naval stores producers in their respective States and to give practical information and demonstrations based on the results of research work at the Naval Stores Station. The services of these cooperative agents were in greater demand than at any time heretofore. Apparently the reason for this is that the prices for turpentine and rosin have been below the cost of production; to make a profit requires the adoption of practices and equipment that will reduce cost of production through greater efficiency and increase the value of products through better quality.

Data on the production, distribution, industrial consumption, and stocks of turpentine and rosin were collected and tabulated by the Washington office of the Division of Naval Stores Research for two statistical reports, under the provisions of an act of Congress, effec-

tive August 15, 1935. One was the regular Semiannual Naval Stores Report, covering the period April 1, 1940, to September 30, 1940, which was issued on November 15, 1940. The other was the 1940-41 Annual Naval Stores Report, covering the period April 1, 1940, to March 31, 1941, which was issued on May 20, 1941. Statistical tables for naval stores products were also prepared for the Department's annual publication, Agricultural Statistics. There is increasing demand for the statistical reports on naval stores from government agencies, financial institutions, business firms, and individuals. Data contained in them furnish the basis for formulation of policy by the Commodity Credit Corporation with regard to loans on naval stores products, and for planning the naval stores program under the Soil Conservation and Domestic Allotment Act.

CHEMISTRY AND TECHNOLOGY OF NAVAL STORES PRODUCTS

Continued research on the resin acids of pine oleoresin and rosin resulted in the development of a procedure which for the first time makes it possible to isolate the sapinic group of acids, free of *l*-pimaric acid, from pine gum. This is based on the Diels-Alder reaction of *l*-pimaric acid with maleic anhydride. By treating a dilute solution of pine gum with a solution of maleic anhydride at low temperatures a condensation product with the *l*-primaric acid is precipitated which can be removed from the medium without altering the other heat-sensitive resin acids. The mixture of resin acids remaining after removal of the *l*-pimaric acid is less complex than the original mixture, and the task of isolating the sapinic group of acids is less difficult. The acids in the residual acid complex were converted into their crystalline ammonium salts and separated by fractional crystallization at low temperatures. By this procedure the sapinic group of acids, free from *l*-pimaric acid, was separated in a crystalline state from American pine oleoresin for the first time. The properties and utility of these acids are now under investigation.

In connection with the procedure for isolating sapinic acids from resin-acid complexes, a method was developed for the quantitative determination of the *l*-pimaric acid content of pine gum. By using this method the seasonal variation of *l*-pimaric acid in longleaf pine gum was determined. Judging from the composition and properties of the *l*-pimaric acid-maleic anhydride condensation product it may find use as an intermediate for dyes of the rhodamine and phthalein types and may also be useful for making synthetic resins of the ester type by combination with glycerin or other polyhydroxyl alcohols.

In connection with the removal of *l*-pimaric acid from pine gum, as the maleic-anhydride condensation product, a new type of "rosin" has been prepared from the *l*-pimaric acid-free gum which has a higher melting point and a higher acid number than ordinary rosin and is of a noncrystallizing character. A rosin with these properties will find preferential uses for certain specific industrial purposes.

Experiments were made on direct crystallization and separations of resin-acid complexes into simpler substances, using low-boiling hydrocarbons as solvents, but the results were not promising. Pentane and other low-boiling petroleum solvents appear to have some possibilities for removing color bodies from pine oleoresin.

Improvements were made in the new multiple-leaf filter designed by this Bureau for use in the fractionation of pine gum. These make the filter more effective and more nearly automatic in operation. A screen of rather coarse-mesh wire cloth, built along the same lines as the filter, effectively removed the "scrape," or oxidized lumps of resin, before filtering and made the mass of gum more suitable for the production of filter cake. Although some of the resin acids are unstable and rapidly become oxidized on exposure to air, it was found that the filter cake can be protected against oxidation for at least a year, by a covering of metal foil. This is an important finding because it means that gum fractions can be kept, without deterioration, until a convenient time for further processing and thus make it possible for gum fractionation to be integrated with gum storage to permit production of naval stores products throughout the year. The resin-acid fractions obtained from undiluted and unheated pine oleoresin by the Bureau's new fractionation technique yield resin and rosin products which differ widely from each other with regard to color, acid content, stability, tendency to crystallize, and other properties. The oleoresin fractions or their rosin products may find specific industrial uses as such, or may serve as sources of particular kinds of resin acids for preparing special chemical products.

Investigations on turpentine during the past year embraced studies on turpentine constituents and derivatives, studies on reaction mechanisms, and other studies vitally, but less obviously, related to turpentine research. This last group dealt with the development of improved fractionating columns for large and for very small quantities of liquid, accessory equipment for vacuum distillations, special vessels for reactions under pressure, and methods for chemical analysis and physical examination of turpentine fractions and derivatives. In view of the complex nature and relative instability of terpenes, the development of suitable equipment and technique is essential for fundamental research on turpentine constituents and derivatives.

The results of some of the Bureau's studies on the minor constituents of turpentine were published as a technical bulletin.

Work was continued on vapor-phase thermal isomerization of alpha pinene and beta pinene with emphasis on the production of highly reactive derivatives (having conjugated systems of unsaturation), such as allo-ocimene, myrcene, and the pyronenes, which are potentially valuable as intermediates for manufacturing synthetic resins or plastics, synthetic rubber, and drying-oil substitutes during the present national emergency. The same equipment and technique were used as in former studies, but the alpha and beta pinenes used were more highly purified (about 99 percent instead of about 90 percent). Composition studies of the reaction products obtained under optimum thermal conditions indicated that the principal products formed by thermal isomerization of alpha pinene are allo-ocimene and dipentene, with smaller quantities of alpha and beta pyronenes. Under optimum conditions about 40 percent of allo-ocimene and about as much dipentene are obtained. It was observed for the first time that the main thermal isomerization product of beta pinene is myrcene, the others being essentially limonene and dimyrcene. About 70 percent of myrcene is obtained under optimum conditions for its formation, together with about 13 percent of *l*-limonene of exception-

ally high rotatory power. By working with beta pinene substantially free from alpha pinene, it was shown that no allo-ocimene is obtainable from beta pinene; this is contrary to reports by previous investigators.

Experiments designed to throw light on the source of the pyronenes obtained in small quantities by thermal isomerization of alpha pinene showed that at an elevated temperature, 410° C., allocimene, the principal isomerization product obtained at lower temperatures, is further isomerized to the extent of about 50 percent into alpha and beta pyronenes in about equal proportions. When alpha pinene was isomerized at temperatures above 375° C. the alpha and beta pyronene content of the product increased at the expense of the allo-ocimene. Apparently no dipentene was formed during pyrolysis of allo-ocimene.

The following conclusions were drawn with regard to the thermal isomerization reaction mechanisms of alpha and beta pinenes: (1) Alpha pinene isomerizes directly to dipentene and allo-ocimene; (2) dipentene is formed by an independent reaction from alpha pinene and not as a product of secondary reaction; (3) alpha and beta pyronenes arise from allo-ocimene reverting to cyclic compounds and not directly from alpha pinene; and (4) both limonene and myrcene are formed directly from beta pinene, and not as the results of secondary reactions.

Samples of myrcene, allo-ocimene, and pyrolized alpha and beta pinenes were sent to the chemical laboratories of several industrial firms for experiments to determine possible uses.

Preliminary experiments on the oxidation of alpha and beta pinenes in the liquid phase with selenium dioxide showed the feasibility of producing the corresponding terpene alcohols myrtenol and pinocarveol, which may be of value in the perfume industry. Improved methods have been devised for extracting these products from the reaction mixtures. Preservation of the original dicylic structure of the pinenes is an essential feature of this oxidation. The utility of the products will be investigated.

In an attempt to find a satisfactory chemical method for quantitative determination of beta pinene in mixtures containing other terpenes, which is badly needed to facilitate the marketing of beta pinene fractions or concentrates, a systematic study was begun on the oxidation of beta pinene by means of alkaline permanganate solution. Incidentally, attention is being given to the properties of the product of this reaction, nopinic acid, which may find industrial uses if it can be produced economically. The highest yield of sodium nopinate obtained thus far, by using considerable excess of oxidizing agent, was 53.8 percent of theory. This was considerably higher than the yield previously reported by other scientists, but still far short of that required for a quantitative method.

Preliminary studies were made of methods for measuring the degree of unsaturation or reactivity of terpenes, a fundamental property of importance for certain industrial uses. In this connection catalytic methods for hydrogenating terpenes were worked out, and a paper comparing the results obtained by hydrogenation with those previously obtained by halogenation and the use of perbenzoic acid was prepared for publication.

USES OF NAVAL STORES PRODUCTS

One of the important uses for rosin is the manufacture of so-called ester gum, a compound of rosin and glycerine, which goes into plastic compositions and high-grade, weather-resistant varnishes and other surface coatings. In order to determine how the properties and utility of this product vary with differences in the resinous material used for its preparation and in the conditions of manufacture, small lots were made in specially designed glass apparatus under carefully controlled conditions. The following resinous materials were used: Longleaf pine rosin; slash pine rosin; wood rosin; vacuum-distilled gum rosin; partially oxidized gum rosin; hydrogenated gum rosin; rosin from the solid portion of pine gum; rosin from the liquid portion of pine gum; abietic acid (optical rotation, $-85°$); commercial stabilized rosin and crystalline acids from commercial stabilized rosin.

There was no relation between the softening point of the ester gum and that of the rosin or other resinous material from which it was made. The products obtained from longleaf and slash pine rosins and wood rosin had essentially the same properties. The products made from abietic acid, vacuum-distilled rosin, hydrogenated rosin and commercial stabilized rosin were softer than the ester gum made from normal gum rosin, as indicated by the temperatures at which they began to fuse. The product made from partially oxidized rosin was harder than that from normal gum rosin; that is, it began to fuse at a higher temperature.

Ester gums made from vacuum-distilled rosin and abietic acid were lighter in color than that made from normal gum rosin. The product obtained from abietic acid was lighter in color than the abietic acid itself in fused form. The product from partially oxidized rosin was darker than that from normal gum rosin.

Above 260° C., the temperature of the reacting mass of resin acids and glycerine had a marked effect on the rate of esterification. Addition of powdered zinc increased the rate of esterification, whereas addition of calcium oxide did not. Abietic acid, vacuum-distilled gum rosin, wood rosin, and crystalline acids from commercial stabilized rosin did not react as rapidly with glycerine as did gum rosin.

The work on utilization of chemical products derived from rosin or pine oleoresin for mildewproofing industrial and farm fabrics was expanded, at the request of the Corps of Engineers of the United States Army, to include rotproofing of sandbag and camouflage fabrics. The naval stores products or derivatives tested for effectiveness in preserving fabrics included copper rosinate, pine tars, pine-tar creosote, pine pitch, pine oil, and pine-oil foots. These were compared with commercial treatments and preservatives, including the cuprammonium treatment, the "Shirlan" (salicylanilide) treatment, copper and zinc naphthenates, pentachlorphenol and its lead salt, phenyl-mercury oleate, copper-ammonium fluoride, and various coal- and water-gas tars.

The existing Army specifications for mildewproofed fabric stipulated that the fabric, when tested by the *Chaetomium globosum* inoculation method devised jointly by this Bureau and the Bureau of Plant Industry several years ago, should not lose more than 10 percent of its tensile strength in 2 weeks. Fabrics treated with pine

tars failed to pass this test. Those treated with copper rosinate and a number of other preservatives did pass it. However, it appeared that this test was not suitable for testing the probable durability of fabrics used in contact with moist soil or sand, because under such circumstances the fabric is subject to bacterial as well as mildew damage, and the service is therefore much more severe. To more nearly simulate service conditions for sandbag fabrics, a simple accelerated rotting test was developed. This consisted of burying the test strips in moist composted greenhouse soil for 2 to 6 weeks and then determining their tensile strength. To further simulate service conditions, fabrics were subjected to light exposure and alternate wetting and drying in a "Weatherometer" before testing them for mildew resistance or rot resistance. It is believed that an accelerated weathering test combined with burial in composted soil will closely simulate the service conditions to which sandbag fabrics are subjected and will therefore serve to measure the relative value of various preservative treatments.

Copper rosinate was found to be more effective as a rotproofing agent for fabrics than other naval stores products and derivatives tested. However, it was not as effective against soil micro-organisms as was copper naphthenate. Weathering reduced the rot resistance of the treated fabrics, probably because much of the treating material was removed by repeated wetting. A suitable waterproofing agent might increase the effectiveness of copper rosinate as a preservative. Pine tars, which had little rotproofing value when used alone, appeared to increase the effectiveness of copper rosinate when used with it. In general, treated cotton had greater resistance to weathering and subsequent rotting, in a soil-burial test, than had similarly treated burlap. It is reported that untreated sandbags last from 3 weeks to 6 months in actual service. Some of the treated fabrics treated in the laboratory lasted 10 times as long as untreated fabric when buried in composted greenhouse soil.

The results of previous studies on the germicidal and detergent properties of rosin soaps were published during this fiscal year. As a consequence of these studies, the Federal specifications for several classes of soap are being revised to permit the use of rosin in combination with other soap-making materials.

SPECIAL RESEARCH IN AGRICULTURE

(Under Bankhead-Jones Act of June 29, 1935)

In addition to the reports under the heading Special Research in Agriculture, reports on other special research projects are given with those on related work under regular financial projects of the Bureau. The results of the special research project on enzyme action at low temperatures are reported with those on chemistry of enzymes under Agricultural Chemical Investigations. Likewise, the results of special research on hemicelluloses and lignocelluloses of cereal straws, hays, and other forage crops are given with those on hemicelluloses under Agricultural Chemical Investigations. The results of special research projects on farm storage of corn, wheat, and grain sorghum, and on uniform and high-density packing of cotton at gins are reported under Agricultural Engineering Investigations.

ALLERGENS OF AGRICULTURAL PRODUCTS

Studies on the chemistry, biological nature, and functions of allergens of agricultural products were continued under a Bankhead-Jones basic-research project. These studies dealt principally with the allergens of cottonseed, but some attention was given also to those of cotton linters, wheat, and ragweed pollen. Five publications were issued during the year.

Allergens are organic substances that cause a variety of ailments, including asthma, hay fever, hives, and dermatitis, in persons who suffer from exaggerated sensitiveness to these substances when they come in contact with or enter the body. They are natural minor components of plant and animal materials, some of which are among the important products of agriculture. Since about 1 person in every 10 is allergic to some substance derived from agricultural products and avoids that substance, and others become prejudiced against certain farm products through unjustified fear of suffering the same effects, it is important that the real facts be learned about the allergens of agricultural products, including their chemical constitutions, properties, distribution, the mechanism of their reactions with components of animal tissues, and, if possible, means for making them innocuous.

The results of the Bureau's research on allergens contribute essential information that aids in the diagnosis, management, or prevention of allergic ailments. This fact is of particular importance to the armed forces of the Nation, for whom the allergy problem is one of great magnitude from both medical and administrative standpoints. One-tenth of an army recruited from the general civilian population can be expected to manifest some form of allergic disorder, or some degree of allergic sensitiveness. Moreover, army field maneuvers are likely to expose men to high concentrations of allergens under conditions that induce sensitization and initiate allergic disease. Under these circumstances the Army must either reject a large number of otherwise able-bodied men or be burdened with their medical care or assignment to limited service, and probably with the liability for compensation claims for service-connected disability. If allergic men are enlisted, not only food and clothing, but all items of equipment that include organic materials must be selected with regard to their allergenic properties.

COTTONSEED ALLERGENS

Previous annual reports of this Bureau have related the progressive fractionation and purification of allergenic components contained in the water-soluble substance of raw cottonseed kernels. The final concentrate resulting from a succession of purifications was a complex combination of protein and carbohydrate units and possessed high allergenic potency and specificity. By a chemical break-down of this substance a protein virtually free from carbohydrate was obtained. This protein was proved to be a natural constituent of the cottonseed; it did not conform with any type of protein in existing systems of protein classification. The Bureau proposed the name "natural proteose" for proteins of this kind.

The principal line of investigation was prompted by the action of the natural proteose when its solution was adjusted to conduct a

direct current of electricity. A sustained high electromotive force caused the most active components of the solution to migrate toward the negative electrode. This method of separating components differing in electrical charge, called electrophoresis, seemed advantageous for separating the protein-carbohydrate allergenic concentrate from cottonseed into its different allergenic components, without altering their compositions or chemical structures, and for obtaining sufficient quantities of the various components for chemical and clinical study.

Four hundred grams of the protein-carbohydrate allergenic concentrate was subjected to preliminary electrophoretic fractionation in special apparatus designed and constructed for the purpose. This preliminary electrophoresis removed a small but important quantity of electrolytes, and thus made it possible to conduct a succession of electrophoretic fractionations with selected cathodic and anodic fractions at progressively higher voltages while keeping the temperature between 20° and 30° C. In the final phase of electrophoresis conducted in a series of six flasks connected by glass tubes providing liquid bridges, four cathodic fractions were separated from the four adjacent flasks nearest the negative electrode and two anodic fractions were separated from the two adjacent flasks nearest the positive electrode.

The individual fractions were subjected to clinical tests and chemical analysis. The cathodic fractions exhibited high allergenic activity, were uniformly high in total nitrogen and protein nitrogen, and were low in carbohydrate. The anodic fractions were lower in allergenic activity and contained significantly less protein, but the outstanding difference between cathodic and anodic fractions was in carbohydrate content. Cathodic fractions contained only about 1 percent, while the anodic fraction averaged 47.5 percent.

Since carbohydrate components play an important role in the specific biological reactions of toxic protein complexes from pneumococci and other pathogenic organisms, it was thought that a similar relationship might exist in the allergens of cottonseed. Allergic tests with electrophoretic fractions showed that the cathodic fractions were more active than the anodic fractions, but this difference in allergenic activity corresponded more closely with the proportions of nitrogen than with those of carbohydrate. For example, one anodic fraction that contained 10 percent of nitrogen and 48 percent of carbohydrate had significantly lower allergenic activity than one cathodic fraction that contained 20 percent of nitrogen and only 1 percent of carbohydrate. This difference in activity might be due entirely to different proportions of the same protein in mixtures containing inactive carbohydrate. It was assumed that if the allergenic activity of the cathodic fraction depended on the 1 percent of carbohydrate, it would be destroyed by treating this fraction with acid. However, drastic acid treatment did not destroy the allergenic activity of the cathodic fraction. From the results of acid treatment and other reactions applied to one anodic fraction, it appeared that part of the carbohydrate was chemically combined with the protein and part was present as a contaminant. The uncombined carbohydrate fraction, isolated chemically, contained 91 percent of carbohydrate and only 2.6 percent of nitrogen. Its allergenic activity was low, corresponding to the small proportion of nitrogen.

The conclusion seemed justified that the carbohydrate component of the allergenic fractions of the protein-carbohydrate concentrate isolated from the water-extract of raw cottonseed kernels does not play an essential role in their allergenic functions, even though it is chemically combined with the protein. The experimental evidence indicated that the concentrate is a mixture of compounds containing the same active protein combined with different proportions of polysaccharidic carbohydrate. Whether such a mixture exists naturally in cottonseed or is produced by the chemical manipulations employed in isolating the active components has not been determined.

WHEAT ALLERGENS

The wheat proteins albumin, globulin, and proteose were prepared and purified by the classical methods of Osborne. Each was evaluated for allergenic activity by cutaneous clinical tests on wheat-sensitive allergic persons. The activity of the albumin and proteose was greater than that of the globulin.

Serious difficulties were encountered in attempting to purify wheat albumin and proteose to the degree required for critical examination of their allergenic properties as individual components. After purifying these fractions according to established methods developed in extensive studies on the chemistry of the wheat proteins, it was found in anaphylaxis tests that animals sensitized with albumin alone or with proteose alone were subsequently reactive to both. According to this evidence, the albumin and proteose fractions were contaminated with each other. By the same criterion, the globulin fraction was free from contamination with either albumin or proteose.

During the fiscal year 1940 this Bureau isolated a heat-stable, diffusible, allergenic fraction from wheat by the same procedure that was used for cottonseed allergens. The allergenic component has not yet been identified. The limited work done on wheat this year indicates that the apparent presence of this allergen in both the albumin and proteose fractions is due to the fact that these proteins cannot be completely separated from each other by present methods.

RAGWEED POLLEN

Allergens, which disturb physiological functions in some people, are closely related to antigens, which cause anaphylactic sensitization of animals when introduced into their blood. Usually an allergen also acts as an antigen. A water extract of ragweed pollen, capable of causing symptoms of hay fever in susceptible persons, seemed to be an exception because it was a poor antigen. But when the active ingredients of pollen were adsorbed on aluminum hydroxide, the combination became a powerful sensitizing antigen. A study directed toward the explanation of this remarkable effect revealed that when a plain water extract of ragweed pollen was injected into guinea pigs only a slight, transitory reaction followed. But when a suspension of the aluminum hydroxide treated with such extract was injected, the subcutaneous tissues at the site of the injection became indurated, forming a nodular mass that persisted for several weeks. During

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this time the animal developed a high degree of sensitiveness to the plain water extract of ragweed pollen. The continuous stimulation exerted by the slowly absorbed antigen probably accounts for the enhanced antigenic potency of the pollen extract.

ANTIGENS OF COTTON LINTERS

An investigation on cotton linters to determine the relationship between the antigen of linters and antigens encountered in house dust was terminated, and the results were published.

The water-soluble antigens of cotton linters and cottonseed kernel were found to be dissimilar and readily distinguishable. House dusts from three sources contained an antigen common to cotton linters of grades commonly used in household furnishings and in the manufacture of cellulose derivatives. However, samples of house dust from different sources were variable and complex with respect to antigen content, containing antigens identified with cotton linters, egg white, and wool. It was not possible to demonstrate the existence of a single characteristic antigenic entity in house dust.

ANIMAL VIRUSES

Chemical studies on animal viruses and the proteins of tumors, a Bankhead-Jones project, were continued by the Enzyme Research Laboratory. Further investigation of the virus of myxoma tumors in rabbits, including purification in the ultracentrifuge, showed that it is not only a complex lipoprotein, as indicated by previous work, but also contains about 4 percent of carbohydrate. Qualitative tests indicated that the carbohydrate component is the rare sugar desoxyribose. This is interesting because the same sugar occurs as a part of many enzymes.

Shope's fibroma virus was extracted from the tissues of inoculated rabbits and purified by means of the ultracentrifuge. This virus also was found to be a complex lipoprotein, its similarity to the virus of myxoma being pronounced. Attempts to prove that the two viruses are identical, or that one can be converted into the other, were not successful.

A second ultracentrifuge, enabling optical analysis of liquids during centrifuging, was constructed, and has been found useful on this project for preliminary runs.

In the course of the work with myxoma protein, partly purified papain was used. This papain behaved in an unusual manner and was therefore studied closely, with the result that a new enzyme was isolated in crystalline form. This new enzyme, to which the name "chymopapain" was given, has been made directly from papaya latex. Its molecular weight, as determined with the ultracentrifuge, is about 45,000, the ratio to that of crystalline papain being 3 to 2. When compared on a weight basis, the new enzyme possesses the same milk-clotting activity as crystalline papain but only half as much protein-digesting activity. These simple whole-number relationships, 3 to 2 and 1 to 2, are interesting from a theoretical standpoint.

The unusual resistance of chymopapain to acids suggested that it might pass through the stomach without injury and therefore be active as a digestant in the upper small intestine, where it would assist the normal enzymes of the pancreas in the digestion of food.

Experiments on rats showed that only about 5 to 10 percent of the ingested enzyme actually reaches the intestine in an active state. While this is not a large proportion, it should be enough to cause considerable proteolysis in the intestinal tract; at any rate, far more than could be produced by the ingestion of any of the well-known protein-digesting enzymes. Application has been filed for a patent covering the new enzyme, chymopapain, and the method for its preparation, in the belief that it may be useful in medicine. This patent is dedicated to the free use of the public.

PLANT VIRUSES

Chemical and pathological studies on plant viruses were continued in cooperation with the Bureau of Plant Industry, with an allotment from the Bankhead-Jones special research fund.

Studies comparing the effects of common tobacco-mosaic virus infection on tobacco grown under conditions of low and high nitrogen supply led to the conclusion that in a susceptible variety there is an abnormally high protein synthesis in the tissues infected by the virus protein, with a simultaneous reduction in quantity of water-soluble protein, as compared with normal plants. A resistant variety on a low nitrogen supply is affected to a slight extent by virus infection, but by increasing the nitrogen supply to normal or above normal it is possible almost entirely to overcome the metabolic interference caused by the infection.

In view of the need for an accurate quantitative method for measuring virus protein, several possible methods were investigated. One in which the nonvirus protein is removed by tryptic digestion proved to be unreliable because less than half the protein in the expressed juice of healthy tobacco leaves was digested. The most promising method was the one that utilizes the fact that virus protein is precipitated quantitatively at its isoelectric point, pH 3.4, whereas only a trace of the nonvirus protein is precipitated at this pH after a preliminary precipitation at pH 4.0 to 4.2. Results obtained by this method indicate that the virus protein content of extracts of diseased tissue can be determined with an error of 5 to 15 percent, the error being much smaller with more concentrated virus preparations.

PRESERVING BIOLOGICAL SPECIMENS RELATED TO AGRICULTURE

Investigation of methods for preserving botanical and zoological material in as nearly natural condition as possible was continued as a basic research project under the Bankhead-Jones Act. Permanent specimens of plants and other living matter related to agriculture, preserved with the natural appearance unchanged, have long been needed for scientific research and for educational and demonstration purposes. The processes under investigation have shown conclusive evidence of meeting these heretofore unattainable requirements, and progress has been made toward simplifying them and making them more generally applicable.

The natural color is retained by treating the fresh material with a polyhydric alcohol borate complex containing various adjuvant substances. After this treatment, which is carried out at a temperature of approximately 0° C., the specimen is cured and dehydrated at room temperature and is then mounted in a transparent, moisture-

proof medium. Several forms of mounting have been developed to meet the requirements of different types of specimens and different uses to which they are to be put. Mounting between flexible sheets of transparent film has been found the most suitable method for the large specimens that can be flattened; for smaller specimens, less than one-fourth inch in thickness, a plate of glass or heavy film with a protective coating of resin is used. Three-dimensional specimens, which can be dehydrated without loss of form or color, are imbedded by means of polymerization in a methacrylate resin.

Improvements resulting in more accurate retention of the fugitive colors and more rapid preservation of perishable material were made through the supplementary use of various dispersing or penetrating agents, the most suitable of which were lecithin, fatty acid esters of mannitol or sorbitol, special abietic acid esters, cyclohexyl adipates, and certain commercial "wetting" agents. It was also found that the alkyl tertiary amines, especially tri-*n*-butyl and mixed triamyl, aided in keeping the shape of some specimens that tend to shrink under treatment. There were indications that these amines had an appreciable effect in retarding photochemical change in chlorophyll subjected to direct sunlight.

Improvements were made in the mounting technique by the use of more suitable resin and drying-oil mixtures for sealing the flexible film sheets and by applying a second pair of films to provide added protection against moisture. Fairly satisfactory resin coatings for specimens mounted on rigid plates were obtained by the use of the polymerized butyl methacrylates and, where baking could be tolerated, of the melamine and urea resins.

Considerable work remains to be done in developing suitable methods of mounting to provide more complete protection against moisture and mechanical injury and to reduce the length of time required for preparing the mount.

Special attention has been given to the application of the process for preserving the natural green of leaves for military camouflage as a means of avoiding detection by infrared photography, and extensive consultation service has been rendered to the War and Navy Departments, with the object of adapting the process to field use. A great deal of work is still needed to meet the drastic requirements of this special application.

SOYBEANS AND SOYBEAN PRODUCTS

Fundamental research relating to the industrial utilization of soybeans and soybean products was continued as a major project under the Bankhead-Jones Act, in cooperation with the Bureau of Plant Industry and the agricultural experiment stations of the 12 North Central States in the Regional Soybean Industrial Products Laboratory at Urbana, Ill.

To aid the agronomic investigations of the influence of variety and environmental factors on the composition of the seed and to guide breeding experiments for improvement of varieties for special industrial purposes, 1,703 samples of soybeans were analyzed. This work required 14,142 individual chemical determinations. In addition, 375 samples were analyzed in connection with utilization research projects. This required about 2,000 individual determina-

tions. Incidental studies were made on the improvement of analytical methods, and 3 articles bearing on the analysis of soybeans or soybean products were published.

Further studies on the treatment of soybean oil with selective solvents have led to the development of an inexpensive process for fractionating the oil into two parts, one having a relatively high iodine number and good drying properties and the other having a low iodine number and enhanced value as an edible oil. The first or unsaturated part is equal, or superior, to linseed oil for use in paints and varnishes, and it is believed that it can be modified chemically to produce a drying oil of the tung-oil type. Research to accomplish this purpose is being expedited as much as possible in order that shortages of imported drying oils, particularly tung and linseed oils, may be filled during the present national emergency by a product of soybean-oil fractionation. Engineering development of these processes to the stage where they are commercially practical should materially change the status of soybean oil in our fat and oil economy. Even in normal times the increased use of soybean oil in the drying-oil field would lessen its competition with lard and cottonseed oil as food products.

Numerous paints and varnishes containing soybean oil have been experimentally prepared and tested for durability, drying speed, and other properties. In regard to durability, paints containing soybean oil alone as the oil constituent compare well with linseed-oil paints. They also adhere well to metals and other surfaces and have a high degree of flexibility. They dry more slowly than linseed-oil paints, which may be a disadvantage for certain uses. Tackiness of the dried film may be more evident than with that of paints containing linseed or similar oils. The tackiness may be greatly reduced by adding a small quantity of maleic anhydride to the oil. Soybean oil to which maleic anhydride was added required less cooking for conversion to a varnish oil and therefore yielded paler varnishes. Several formulas were developed for traffic or road-marking paints in which soybean oil was used in the varnish vehicle. These paints are being tested in the vicinity of the laboratory and by the highway department of a middle-western State. The research on soybean oil paints has promoted increased use of soybean oil by paint and varnish manufacturers. Recently a commercial firm has put on the market a soybean-oil paint in paste form, to be mixed with an equal volume of soybean oil to make paint for the exterior of farm buildings.

Low-temperature crystallization of soybean-oil fatty acids from a solution at −35° C. made it possible to obtain a 75-percent fraction having an iodine number of 162. The pentaerythritol esters prepared from this fraction of the fatty acids equaled linseed oil in drying speed.

Further work was done on the complete molecular distillation of crude soybean oil and analysis of the fractions obtained. Fractionation of the glycerides was accomplished to an appreciable extent. Unsaponifiable matter and free acids were concentrated in the first fraction.

The solid material separated from soybean oil by chilling and filtration in the commercial process of winterization was found to contain about 10 percent of free solid alcohol in addition to true

wax (esters of long-chain fatty acids and alcohols). No free acids and apparently no hydrocarbons are present. The principal alcohols contain from 32 to less than 28 carbon atoms, and the acids have an average chain length of about 22 carbon atoms. The wax amounts to not more than 0.002 percent of the original oil.

In further studies of the reversion of refined soybean oil for the purpose of learning how to improve stability, special attention was given to the factors affecting the decomposition of peroxides formed by partial oxidation of the oil. Most studies of the relation of peroxides in oils to the development of rancidity have been concerned with the cause and rate of peroxide formation. However, the decomposition of the peroxides is important, since their decomposition products are apparently responsible for the properties that characterize rancid oils. Experiments with a sample of edible soybean oil that had been given a high peroxide value by aeration at 55° C. showed that at a moderate temperature (25° C. or 77° F.) light promotes decomposition, ultra-violet light being more effective than diffused daylight. But heat also causes rapid decomposition of peroxides in the absence of light at higher temperatures. It appears that light is relatively more potent than heat in promoting the formation of peroxides, while the order is reversed for their decomposition. During the year four articles bearing on the stability of vegetable oils, as typified by soybean oil, were published.

Further research was directed toward the separation of protein from soybean meal and ascertaining the physical and chemical properties of soybean protein that are important in its industrial uses. Protein extracted from soybean meal with water and precipitated by electrodialysis had an isoelectric point (at which coagulation occurs) of pH 4.2. Purification by repeated solution, precipitation, and washing changed this point to pH 4.5. Salt-extracted protein had an isoelectric point of pH 5.5. Formaldehyde-treated protein invariably had a lower isoelectric point than did the original protein, the difference being usually from 0.3 to 0.6 of a pH unit.

Limited study of the reaction of formaldehyde with amino acids led to the belief that more than one type of linkage is formed in this reaction. Sufficient fundamental knowledge is not yet available to make possible the control of conditions well enough to obtain a specific compound. Because of the results with amino acids and the change in the physical properties, the action of formaldehyde on protein is thought to cause a cross linkage between amino groups, resulting in a three-dimensional polymer difficult to plasticize.

Experiments were also made on the modification of soybean protein by acetylation. Attempts to acetylate with acetic anhydride were not very successful; not more than 20 percent of the primary amino groups were blocked off, as determined with the Van Slyke apparatus. Apparently complete acetylation was obtained with ketene when soybean protein, suspended in a saturated solution of borax or trisodium phosphate, was treated with this reagent. The reaction was most rapid and complete in a pH range of 9 to 11. The color of the acetylated protein was satisfactory. The product remained soluble after treatment with formaldehyde. When hydrated, it was soluble in 70-percent alcohol and in ethylene glycol, indicating a reduction in the polar groups of the protein.

From a consideration of the properties of the amino acids in soybean protein, it was believed that deamination of the protein with nitrous acid would alter its properties in a way similar to that brought about in the reaction with formaldehyde but would avoid cross-linking, which is believed to be responsible for the reduction in plastic and adhesive properties. Experiments were made first with an individual amino acid, tyrosine, and then with the soybean protein. The results indicated that in the treatment with nitrous acid deamination and diazotization are competing reactions at a pH between 3 and 5. Apparently the desired reaction, deamination, progresses at the faster rate. Because of increased water resistance and other desirable properties of the deaminated protein, its use in plastics and fibers is to be investigated. The color is objectionable, but it may be possible to bleach the product by reducing the nitro and diazo groups.

An improved apparatus and experimental technique were developed for measuring the dielectric constants, at audio and radio frequencies, of protein solutions having low conductivity. Also, a simple relationship was discovered between the polarization capacity and frequency that aids in the interpretation of dielectric constant measurements on protein solutions. The measurement of dielectric constants of solutions has become a standard method of protein research. These constants indicate the dipole moment and therefore the molecular structure. From the radio-frequency dispersion of the dielectric constant the molecular size and shape can be calculated. The problem of bound water and the effects of chemical modifications of the protein may also be studied by this method.

A soybean meal-phenolic resin plastic that is a great improvement over previous similar preparations in regard to water resistance was made in the laboratory. The components were the same as in previous preparations, namely 3 parts each of soybean meal, phenolic resin, and wood flour, but the phenolic resin, instead of being added in dry pulverized form to dry formaldehyde-hardened soybean meal and dry wood flour, was produced in the presence of the soybean meal by what may be called the wet process. By this procedure the soybean meal undoubtedly was hardened at the same time the phenolic resin was polymerized. Tests on this plastic in the laboratory and by industrial plastic molders showed that it had good molding properties. The product cured as fast or faster than commercial molding resins of the same type, was perfectly homogeneous, and had a good finish. Water absorption in a 24-hour immersion test was 0.6 percent, whereas that of test pieces molded from the 3:3:3 mixture previously made by the dry process was 3 to 4 percent.

A public service patent was granted for a laminated product made with soybean protein plastic, the properties of which, except for water resistance, are comparable to those of laminated products made with commercial synthetic resins.

Azo-dye lakes were found to be the most stable colors for soybean-phenolic molding plastics. Phthalocyanines and azo dyes, in general, are satisfactory. Variation in shades may be obtained by using such pigments as titanium dioxide, zinc sulfide, zinc chromate, and burnt umber. These colors are more permanent in the mixed protein-phenolic than in the straight phenolic plastics.

It has come to the attention of the laboratory that several manufacturers of phenolic molding powders have recently begun to use

soybean meal in some of their products and are getting advantageous results. Addition of soybean meal to a phenolic resin increases impact strength and permanence of the color, lowers the specific gravity, and in some cases improves the flow characteristics of the resin.

Experiments on the variation of the adhesive strength of soybean protein by mild hydrolytic treatment with solutions of alkali and alkaline salts yielded results that point to the most advantageous methods of using soybean protein with white clay or other pigment in the manufacture of coated paper. It appears that in most of its properties soybean protein is equal to casein for paper coating. Soybean protein coatings are somewhat more oil resistant. Specially designed equipment has been assembled for experiments on the production of fibers and films from soybean protein.

Research at Indiana Agricultural Experiment Station, in cooperation with the Regional Soybean Industrial Products Laboratory, has contributed further fundamental knowledge regarding methods of isolation and the characteristic properties of components of the carbohydrate fraction of soybean meal and of the sterols and phosphatides in soybean oil.

Cooperative research at Minnesota State Agricultural Experiment Station on the respiration and storage behavior of soybeans is yielding information on the moisture content of soybeans likely to cause damage under particular storage conditions.

REGIONAL RESEARCH LABORATORIES

(Conservation of Agricultural Resources, under Agricultural Adjustment Act of 1938)

The four Regional Research Laboratories, provided for by the Congress in accordance with Section 202 of the Agricultural Adjustment Act of 1938 and placed under the administration and operation of this Bureau by an order of the Secretary of Agriculture dated October 6, 1938, were completed and occupied during the fiscal year 1941. Construction work on the administrative units and chemical laboratory wings of all four laboratory buildings was started in June 1939. The first to be completed was the Eastern Regional Research Laboratory at Wyndmoor, Pa., which was occupied on August 17, 1940, and the last was the Southern Laboratory at New Orleans, La., which was occupied on April 11, 1941. Construction work on the industrial wings of the four laboratories, built under later contracts, was started in February 1940. The first to be completed was that at the Northern Laboratory in Peoria, Ill., accepted January 20, 1941, and the last that at the Southern Laboratory, accepted June 28, 1941. Sixty-five out of 288 research-laboratory units were equipped and in use during the past fiscal year; contracts were awarded for equipping 125 more; and 98 remained to be equipped in 1942. Special equipment, including some for pilot-plant experiments on processes previously developed on a laboratory scale, will be purchased and installed in the fiscal year 1942.

During the early part of the year the divisional organization of the laboratories was completed. Selection and appointment of qualified research workers and other necessary personnel were continued, and toward the close of the fiscal year the total number of perman-

ent employees in the four laboratories was 508. It was expected that about 350 more, mostly in lower and intermediate grades, would be appointed in 1942.

Active laboratory work on most of the approved commodity projects of the Regional Research Laboratories has been in progress only during the latter part of the year, because the year was well advanced before the buildings were accepted and the necessary equipment was installed. Work on some old projects transferred to the Regional Research Laboratories from former divisions of the Bureau and on some new national defense projects under the laboratories was carried out in the Washington laboratories pending the acquisition of needed facilities by the Regional Research Laboratories. Much time and effort were devoted to detailed planning and formulation of the research line projects to be conducted under the general commodity and work projects; to the coordination of proposed lines of work with those already in progress; to searches of scientific and technical literature dealing with the chemical and physical properties and the utility of agricultural commodities and their components, and the industrial practices, processes, and requirements for utilizing such materials; and to the selection, specification, and procurement of equipment and supplies for the individual laboratories and pilot plants.

The progress of research by the Regional Research Laboratories during the past fiscal year is briefly reported here under the individual commodities or commodity groups selected for investigation.

CORN

The Northern Regional Research Laboratory, in cooperation with various State agricultural experiment stations and the Bureau of Plant Industry, has collected a large number of representative samples of corn already being produced commercially and also being studied experimentally by geneticists. These samples are being analyzed in order that any differences that might affect the industrial utilization of the different varieties may be ascertained and serve as guides for the research work. Included are samples of corn stored over a period of years in connection with the Ever-Normal Granary program, in order to determine whether such storage affects various industrial uses in which corn may find an outlet.

Investigations dealing with the development of new and wider uses of cornstarch and dextrose are well under way. Much effort has been devoted to the assembly, installation, and erection of equipment to carry out the necessary research work. A considerable number of samples of native or untreated starches have been prepared from different varieties of corn, including both open-pollinated and hybrid varieties, as well as a number of samples of waxy-maize starch, which is reported to have properties similar to tapioca starch.

Preliminary work has been started on a study of production of dextrins from cornstarch, having in mind requirements which are developing out of the shortage of imported starch. Work was initiated on the chemical treatment of dextrose for the production of derivatives, such as glycerol. These studies include investigations on the development of useful plastic substances using dextrose as a source material. Basic studies on the possibility of producing from cornstarch, materials having fiberlike properties have also been initiated.

Experiments are in progress on the fermentation of corn mash to 2,3-butylene glycol by *Aerobacter*, in an effort to produce a starting material for butadiene and artificial rubber. The problem of recovering 2,3-butylene glycol from the fermented liquors is also being investigated. Further explorations are being made of the possibility of using molds and bacteria of the genera *Pseudomonas* and *Acetobacter* to produce useful products by the fermentation of glucose or corn sugar. This work is a sequel to the successful development by the former Industrial Farm Products Research Division of two patented processes, one of which has been licensed by six companies and is now being used industrially for the conversion of glucose to 2-ketogluconic acid and *d*-isoascorbic acid. The other process for the production of 5-ketogluconic acid by *Acetobacter* may be used by industry in the near future, and has already been licensed by two companies. Another fermentation study in progress is directed toward the production of itaconic acid, which will find a place for itself in the plastics industry.

A collection of over 3,000 identified micro-organisms of industrial significance, including yeast, molds, and bacteria, has been assembled. This collection is of great importance in the development of industrial fermentation processes based on corn and other agricultural materials and may be of wide national use in view of the fact that a similar collection of world-wide importance has apparently been lost by virtue of the Nazi occupation of Holland.

The erection and installation of equipment for an experimental alcohol pilot plant which will have a capacity of approximately 500 gallons of anhydrous alcohol per day, produced by the fermentation of corn and other agricultural commodities, is actively under way and is being expedited to the fullest extent possible. Considerable experimental work on a laboratory scale has been done in connection with the selection of suitable yeasts for use in this plant, as well as the determination, in small experimental flasks, of optimum operating conditions with respect to organism, mash, temperature, and the like.

Equipment is being procured for the erection of a small pilot plant for the processing of corn to starch, protein, and oil. This equipment will be utilized for the study of methods for the improvement in yields and economy of operation with respect to current and new methods for the processing of different varieties of corn.

Investigations are actively under way on corn oil, with particular reference to the modification of its component unsaturated fatty acids. Studies dealing with the chemical modification of these unsaturated acids to materials possessing properties similar to those of the component unsaturated acids of tung oil are being emphasized. These investigations are of great importance because of the shortages which are developing in tung oil. Another phase of this work is concerned with the development of sulfurized derivatives of corn oil for use as extenders in natural and synthetic rubber.

Work has been initiated on the development of a new process for extracting zein from corn gluten as a means of lowering the cost of the product and improving its stability. The tendency of zein films to blush on contact with water and the ease with which zein

gels in alcohol solution are deterrents to the wider use of this potentially important protein. The new process is expected to minimize this tendency.

WHEAT

A survey of the current wheat situation was made by the Northern Regional Research Laboratory in cooperation with other agricultural agencies in order to determine what grades of wheat might be considered as the best possible sources of industrial raw materials. Collection was made and analysis is under way of a large number of samples of wheat from various parts of the country, in cooperation with State agricultural experiment stations and the Bureau of Plant Industry, for determination of such chemical and physical properties as may be of industrial significance and which are not now being determined by other agencies.

Samples of wheat starch have been collected for the purpose of determining the characteristic properties which may be of significance in evaluating the present or developing new industrial uses. Special attention is being given to the processing of wheat to produce wheat starch, and equipment is being designed for this purpose. Surveys have been made to determine possible outlets for wheat starch in specialty fields, and provision has been made to improve methods now used for the manufacture of wheat starch from both the technical and economic viewpoints.

Investigations are in progress on the chemistry of the component fatty acids of wheat oil, as well as on the analysis of the oil itself.

A portion of the work being done at the Northern Regional Research Laboratory on corn and its derivatives is equally applicable to wheat and applications will be made wherever possible.

Methods of isolation and recovery of gluten protein from wheat received preliminary laboratory study in the Western Regional Research Laboratory, with attention to relative merits of different procedures suitable for the identification and characterization of gluten protein fractions and components. It was noted that wheat gliadin has unusual coherence and extreme extensibility, which suggest its possible use for artificial protein fibers to replace silk.

AGRICULTURAL RESIDUES

New and increased industrial utilization of agricultural residues is dependent on the development of more economical methods of collection, as well as on the working out of new processing methods and the development of new uses for these residues and their derived products. Investigations on harvesting and collecting agricultural residues were continued at the Northern Regional Research Laboratory in cooperation with the Bureau's Division of Farm Mechanical Equipment, various State engineering and agricultural experiment stations, and farm equipment manufacturers. These investigations have already resulted in the development and manufacture of special baling equipment, which will be subjected to further field tests.

Surveys were made on the location of agricultural residues such as corncobs, cottonseed hulls, wheat straw, and flax shives, in order to determine the quantities of these materials actually available for industrial use and the relation of their locations to transportation, consump-

tion centers, and established industry. A large number of samples of these various residues have been collected, in cooperation with State agricultural experiment stations and the Bureau of Plant Industry, and prepared for experimental use in the Laboratory.

Laboratory work has been initiated and is under way on the development of low-cost building materials which may be manufactured and used on farms and in rural communities. The work on lignin plastics, previously carried on at the Bureau's Agricultural Byproducts Laboratory in Ames, Iowa, is being continued on an expanded scale at the Northern Regional Research Laboratory. These plastics may be produced from materials such as corncobs, cornstalks, flax shives, wheat straw, and bagasse.

Furfural, a chemical used widely in industry for solvent purposes and for making plastics, is commercially produced from agricultural residues to the extent of about 6 million pounds annually. The potential supply of this chemical is enormous. Active work is under way for the development of new uses and wider markets for furfural. Specifically, as an emergency problem, investigations on the production of synthetic rubber intermediates from agricultural residues by way of furfural, are actively under way. These experiments are very encouraging and point to the definite possibility of obtaining a relatively low-cost intermediate which may be used in the production of synthetic rubber in a manner analogous to the current use of butadiene.

Studies are also actively under way on the saccharification of agricultural residues to materials which may be useful in a number of fields, particularly through the application of fermentation reactions. This work has dealt largely with the determination of equilibrium constants pertaining to the sugars formed as a result of the action of acids on the residues concerned.

Marked progress has been made in the installation of special pilot-plant equipment for producing plastics and cellulose pulp from agricultural residues. A pulp-and-paper laboratory and also a plastics and special building-materials laboratory are being built for the thorough testing of all materials which may be developed in these fields.

Encouraging results have been obtained from experiments conducted on the development of a generator for the production of combustible gases from corncobs, for use as a source of heat, light, and power on farms or in small rural communities.

COTTON

Delay in completing and equipping the Southern Regional Research Laboratory prevented actual laboratory work there during the fiscal year 1941. However, laboratory work on special problems relating to uses of cotton for national defense purposes was carried on in Washington by personnel detailed from the Southern Laboratory.

In studies on the protection of cotton sandbags against deterioration by micro-organisms, it was found that the proportion of copper left in the fabric by impregnation with solutions of copper compounds, such as copper naphthenate, had to be greater than that required for other types of fabrics. It could be substantially reduced if the copper

compound was used with a weather-resistant binder or waterproofing agent, such as pine tar or water-gas tar.

Attention was also given to problems involved in using lint cotton in the manufacture of smokeless powder to meet a possible contingency of inadequate supplies of cotton linters, commonly used for that purpose. The much greater length of lint cotton, in comparison with linters, introduces mechanical difficulties, interferes with the progress of the chemical reactions and results in nonuniformity of product. Experiments on a laboratory scale indicated that lint cotton can be satisfactorily substituted for linters if it is cut to a length approximating that of linters. With the cooperation of the Council for National Defense, a firm producing cellulose for use in smokeless powder, and the Naval Powder Factory at Indian Head, Md., arrangements were made to cut lint cotton on special machinery; to purify, bleach, and nitrate this cut cotton; and then to convert the resulting guncotton to smokeless powder, all on a commercial scale. Orders have been placed for the necessary cutting equipment.

Experiments with cotton have demonstrated that bales having a thickness of 20 inches and a density of 30 pounds or more per cubic foot successfully resist pentration by M2 ball-type bullets fired from a .30 caliber Enfield Army rifle. It is planned to extend these experiments in cooperation with the War Department to determine whether cotton bales can be used for protection against projectiles of larger size and bomb fragments. A closely related problem, the fireproofing of cotton bales, is being investigated by the Division of Naval Stores Research.

Studies were made of the suitability of black cotton fabrics of different types for obscuring lights in defense against aerial attacks at night, and the cotton textile industry was surveyed to learn which of the fabrics suitable for the purpose can be produced in largest volume.

The suitability of cotton cloth and lint cotton in conjunction with plastic materials for molding protective helmets and street-lamp shades was also investigated, with promising results.

In cooperation with the Wyoming Agricultural Experiment Station and the owner of a sheep ranch in Wyoming, experiments are in progress to determine the effectiveness and practicability of specially designed cotton rugs to be used as sheep coats for reducing the need for supplementary feed in severe winter weather and for protecting sheep after shearing in cold weather.

A special type of cotton bag was designed for and accepted by the Agricultural Adjustment Administration. These bags, which may be probed for samples without leaving a permanent hole and which have a specially constructed seam to prevent the passage of seeds, are to be used for the distribution of hairy vetch and Austrian winter pea seeds.

A cooperative investigation with the Northern Regional Research Laboratory has been started on the pulping method for removing second-cut linters from cottonseed hulls to replace the cumbersome and very costly cutting method now used in the industry. A report on Trends in the Consumption of Fibers in the United States, 1892–1939 has been published; one on Registered Trade Names Applicable to the Finishing of Cotton Textiles is in press; and a complete bibliography with abstracts of the literature on the chemistry, technology, and utilization of cottonseed and its derived products, for the period 1830–1939, has been compiled for publication.

SWEETPOTATOES

Pending the installation of laboratory and pilot-plant equipment at the Southern Regional Research Laboratory, a thorough review has been made of the recent work on sweetpotato starch, dehydrated sweetpotatoes, and sweetpotato flour carried out by the former Carbohydrate Research Division of the Bureau and cooperating agencies, and of the earlier work on sweetpotato sirup, to obtain a clear perspective of the progress of this work to date. A broad plan has been developed for continued and expanded research without interruption by transfer of responsibility. It contemplates evaluation of new varieties of sweetpotatoes for starch content and processing quality, modification of the manufacturing process to reduce costs and improve the yield, quality, and uniformity of sweetpotato starch, and development of methods for storing sweetpotatoes without impairing their quality for industrial utilization.

Cooperative relationships have been established with other Federal and Mississippi State agencies and with Sweet Potato Growers, Inc., the farmers' organization which operates the sweetpotato-starch plant at Laurel, Miss.

PEANUTS

Laboratory investigations are under way to establish the constitution of a hard wax, presumably prepared from peanut oil, which has been imported into the United States until recently. This imported material is a costly product used to impart high gloss to patent leather. It is also used in certain cosmetics and metal finishes. Efforts will be made to duplicate this product, starting with domestic peanut oil.

A complete bibliography with abstracts of the literature on the chemistry, technology, and utilization of peanuts and their derived products, covering the period 1830-1939, is being assembled for publication.

FRUITS (IN GENERAL)

In cooperation with the Division of Agricultural Chemical Research, frozen packs of some fruits were prepared at the Frozen Pack Laboratory in Seattle, Wash., in connection with studies on the influence of variety, stage of maturity, pretreatment, enzyme action, and temperatures of freezing and storage upon the quality of the products. Strawberries, raspberries, blackberries, and peaches grown in plant-breeding experiments conducted by the Bureau of Plant Industry in cooperation with western State agricultural experiment stations were tested in experimental packs to determine their suitability for preservation by the quick-freezing process. A pilot plant that will facilitate frozen-pack studies is under construction at the Western Regional Research Laboratory which will take over all such studies in this Bureau beginning with the fiscal year 1942. Some attention has been given to improving the design of cold-storage equipment for individual farm use.

Recovery and processing of oil from fruit seeds and pits has been the subject of an investigation during the closing months of the year, at the Western Regional Research Laboratory, and will be continued. Attention was devoted to economic factors involved and

refining problems. Research was started on the chemistry of saturated fatty acids and their glycerides with a view to the preparation of new and useful derivatives.

Investigations of the microbial content of quick-frozen fruits were conducted with a view to improving sanitary conditions before and during the packing operations and also accumulating more data on the survival of micro-organisms in frozen-pack fruits.

Extensive chemical analyses and testing of various fruits to determine their utility were begun. Studies initiated toward the latter part of the fiscal year were concerned with the possibilities of lowering the cost of preparing pectin from fruits, utilizing fruit culls and wastes as sources of vitamin concentrates, and the microbiological production of yeast proteins, vitamins, and other useful products from surpluses and wastes of fruits that are rich in sugars. Procedures for composting low-grade fruit wastes such as grape pomace are also under investigation.

APPLES

Experimental work on apples was done by the Western Regional Research Laboratory partly in cooperation with the Division of Agricultural Chemical Research at the Fruit and Vegetable By-products Laboratory in Pullman, Wash., and by the Eastern Regional Research Laboratory with its own facilities and in the plant of a cooperating commercial firm in New England.

In the western region small experimental packs of apple juice were canned and stored to show the effects of variations in processing, type of container, and temperature and time of storage on the quality of the product. Experiments on the production of galacturonic acid by acid and enzymic hydrolysis and of certain demethoxylated derivatives of pectin have been undertaken. Laboratory and small-plant-scale studies were made on the preparation of a free-flowing, stable apple powder with a low moisture content. Apple powder has been studied abroad to some extent and a similar product has found some use in this country for treating intestinal disorders. Experiments on the quick-freezing of apple slices for use in pies and methods for preventing the discoloration of frozen apple slices, previously begun by the Food Research Division, have been continued with encouraging results. A study is in progress on microchemical and physical methods for the detection and determination of trace elements, such as iron and tin, which may contaminate and cause flavor deterioration in apple products.

In the eastern region, in collaboration with the National Apple Institute, samples of canned apple juices representing the 1940 packs of practically all firms in the apple-juice packing industry were collected, analyzed and tested for quality to show what had been accomplished in the way of quality improvement, and how quality was affected by variety and grade of apples used, degree of maturity, processing method, type of container, and other factors. The results of this survey, reported at the annual meeting of the Institute and distributed in mimeographed form, will undoubtedly help some of the packers to improve their products.

Laboratory studies were made on the isolation of the volatile esters which are responsible for the flavor and aroma of apples, and a method was developed for determining the quantity of such

constituents present in apples and apple products. In the concentration of apple juice the esters are volatilized, but means were previously developed at the Pullman, Wash., laboratory for recovering them by condensation, so that they might be reconstituted with the concentrated juice. In experiments on the concentration of apple juice, using commercial equipment of a cooperating packer, the impregnation of concentrated apple juice with esters by passing through it the most volatile portion of the vapors from a subsequently concentrated batch of juice was found to be impractical because of excessive loss of esters. This experience was of value in designing an apple juice concentrator for use by the Eastern Regional Research Laboratory in the fall of 1941.

Experiments were made at the Eastern Regional Research Laboratory on the processing of apple juice with pilot-plant equipment to determine the effects of apple variety, deaeration of juice, centrifuging, filtration, pasteurizing time and temperature, and type of container on the quality of the product. This work required the packing of a large number of apple-juice samples. Some tentative conclusions from examination of the canned samples after 4 months in storage were: That filtration removes some of the flavoring constituents, whereas centrifuging does not; that deaeration has no effect on the quality of the juice; and that the type of container has a decided effect on the quality of the juice.

A special type of apple pectin, for other than the customary uses, is being developed in cooperation with the Delaware Agricultural Experiment Station.

VEGETABLES (IN GENERAL)

The Western Regional Research Laboratory collaborated with the field laboratories of the Division of Agricultural Chemical Research located at Los Angeles, Calif., and at Seattle and Pullman, Wash., and with horticulturists of the Bureau of Plant Industry and western State agricultural experiment stations in studies on the utilization of vegetables.

In connection with the quick-freezing method of preserving vegetables, further studies were made of the preliminary blanching or scalding treatment as a means of inactivating enzymes which might cause deterioration in the packed material. Attention was given to the relations of package type and storage temperature to losses in weight and quality of frozen peas. Various types of containers for frozen vegetables were studied with regard to their relative effectiveness in preventing the passage of moisture and water vapor, and recommendations were made to guide packers in the choice of protective materials and help them improve their methods of sealing packages. Investigations were continued on the application of chemical and physical tests to the grading of raw vegetables intended for freezing. In cooperation with the Agricultural Marketing Service, considerable time was spent in gathering fundamental information to be used as a basis for the development of consumer grades for frozen Lima beans, cut corn, and asparagus. Field and packing-plant studies were made of the possible and actual sources of microbiological contamination of frozen-packed vegetables and led to suggestions of remedial measures. Further progress was made in

the problem of developing a direct bacteriological test for frozen vegetables in order to avoid the cumbersome culture method which detects only living organisms, and in the related problem of formulating a basis for bacteriological standards for frozen vegetables.

Because of its important bearing on national defense, the dehydration of foods, especially vegetables, is receiving special attention at the Western Regional Research Laboratory. The principal objective is improvement in quality of dehydrated products to make them more acceptable to consumers.

Procedures for composting low-grade vegetable wastes, such as asparagus butts, are under investigation.

In experiments on the utilization of vegetable wastes it was found that certain wastes, like asparagus butts and artichoke tops, may be separated by mechanical means into a fibrous portion and an essentially nonfibrous colloidal portion, the first of which, either alone or mixed with a certain proportion of the second, may be given a permanent form by pressing and drying. On the basis of these experiments, application was filed for a patent on a new fiberboard and process for making it in various densities to be used for heat-insulating or structural purposes. This was the first patent application resulting from the work of the Regional Research Laboratories.

At the Eastern Regional Research Laboratory studies were made on the drying of waste pea and Lima bean vines from commercial plantings for possible use in feeds and industrial products. The dried materials are to be subjected to chemical study in order to isolate and identify constituents having possible industrial uses. The value of these dried vegetable wastes for use in stock feeding will be determined through cooperative work by the Division of Agricultural Chemical Research and the Bureau of Animal Industry.

POTATOES

In the Western Regional Research Laboratory consideration was given to processes and equipment suitable for dewatering or dehydrating potatoes for industrial uses to reduce their weight, bulk, and perishability in storage. Methods for following changes in the physicochemical properties of potatoes during processing and storage are being studied critically. Data on the location and quantities of cull, low-grade, and damaged potatoes at concentration points in the western region are being collected and studied in connection with the economics of potato utilization.

In the Eastern Regional Research Laboratory preliminary experiments were made on the dextrinization of potato starch in such a way as to form a superior product for preparing the adhesive coating on gummed paper, envelopes, and postage stamps. The use of domestic potato starch for this purpose would create an extensive outlet for surplus and cull potatoes. Considerable attention was given to the technology of preparing potato starch, with the object of increasing the quantity and improving the quality of potato starch made in this country. High-quality potato starch has characteristics which make it especially suitable for certain industrial uses and it commands higher prices than other starches. In the past most of our supply has been imported from Germany and Holland.

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ALFALFA

Toward the close of the fiscal year a preliminary study was begun at the Western Regional Research Laboratory on the possibilities of various procedures for the mechanical disintegration of green alfalfa plants preparatory to extraction of the chemical constituents. The recovery, concentration, and utilization of vitamin A, or its precursor carotene, and the preparation of high-protein food concentrates from alfalfa will receive special attention because of their importance in the present national emergency.

POULTRY PRODUCTS AND BYPRODUCTS

Pending the completion of a pilot plant at the Western Regional Research Laboratory for the quick freezing of food products, a preliminary experiment on the quick freezing of poultry was made in the plant of a cooperating commercial firm. Frozen eviscerated chickens prepared with several kinds of dressing and accompanied by fruits and vegetables suitable for a complete frozen-pack dinner found ready acceptance by consumers. The comments received were generally very favorable; some suggested possible improvements in technique. The effects of changes in moisture content during quick freezing and storage on the structure and quality of poultry are being studied.

Preliminary work was done on the utilization of egg albumen for industrial adhesives and thermoplastic closures. Methods for determining the physical and chemical changes that take place in eggs during frozen storage are being developed.

Exploratory experiments were started to determine the relative merits of various solvents, dispersing and modifying agents, and treatments for converting the keratin proteins of chicken feathers into industrially useful forms.

TOBACCO

Knowledge gained in preliminary laboratory experiments at the Eastern Regional Research Laboratory on the isolation of aromatic chemical compounds from tobacco is being used in planning large-scale operations for the recovery of these compounds in quantities sufficient for purification and identification. A large-scale experiment was started in cooperation with a manufacturer of tobacco products to determine what chemical changes take place in tobacco during the fermentation process.

Laboratory and pilot-plant studies on the recovery of nicotine from tobacco by vacuum distillation showed that during the first stages of distillation nearly pure water comes off and that the concentration of nicotine in the distillate increases toward the end of the distillation. When nicotine solutions of more than 7-percent concentration were heated to 70° or 80° C. a nicotine solution of 80-percent concentration formed as a separate layer and could be withdrawn. These results are expected to aid in simplifying the process of obtaining nicotine from surplus and waste tobacco, which should result in lower cost and more extensive use of this valuable insecticide. Results obtained in these preliminary investigations were useful in designing larger pilot-plant distillation equipment for use in studies on separating nicotine from tobacco.

New compounds of nicotine, including a considerable number of double salts of nicotine and various metals, were prepared in the laboratory; large quantities will be prepared later for cooperative tests by the Bureau of Entomology and Plant Quarantine on their insecticidal value. In preliminary experiments on the fixation of nicotine, ground rubber and cellulose appeared to have some promise as carriers which will retard the dissipation of nicotine when applied to plants.

Possible methods of oxidizing nicotine to nicotinic acid were studied, in comparison with present commercial methods of synthesizing this product from other chemicals, in order to determine if nicotine can successfully compete with these other chemicals as a source of this important food accessory which exists naturally in the vitamin B complex. Because of the present practice of fortifying wheat flour with nicotinic acid and other vitamins of the B complex, to increase the nutritive value of bread, an unusual demand has been created for this substance. If it can be made economically from nicotine, this might provide an important outlet for surplus or high-nicotine tobacco that can be grown in place of ordinary tobaccos.

MILK PRODUCTS

In November 1940 equipment became available at the Eastern Regional Research Laboratory, for experimental work on the industrial utilization of the constituents of skimmed milk and whey, the principal dairy byproducts. Exploratory experiments were made on the fractionation of casein and whey proteins with inorganic salts and acids and with certain organic acids. Twenty-seven substances were subjected to initial investigations in a fundamental study on the absorption of water in the vapor phase by various proteins, peptides, and amino acids, the results of which may show how to improve the quality of protein plastics and fibers in general and those made from casein in particular. Special apparatus for use in this study was devised and constructed. A flexible and accurate type of apparatus for the experimental production of casein fiber, in continuation of the work heretofore done by the Bureau of Dairy Industry, was designed and is being constructed.

Initial laboratory work bearing upon the utilization of lactose (milk sugar) was directed toward the economic conversion of its fermentation product, lactic acid, into acrylic esters and acrylonitrile, a problem that had previously received some attention in the Bureau of Dairy Industry and the former Industrial Farm Products Research Division of this Bureau. The desired products are important intermediates for the synthesis of acrylate resins and certain rubber-like products. Lactamide was prepared successfully by treating methyl lactate with aqueous ammonia, anhydrous ammonia, or ammonium carbonate. The reaction of methyl lactate with anhydrous ammonia affords a convenient method of preparing lactamide of excellent quality in high yields. Other means for converting lactic acid to lactamide are still under investigation. Further study is required to learn the potentialities of processes of this type and to determine the conditions under which best results can be achieved. Lactamide may become a competitor of acetamide in chemical uses as a special solvent and intermediate for the synthesis of acrylonitrile.

ANIMAL FATS AND OILS

Experimental work at the Eastern Regional Research Laboratory on the utilization of animal fats and oils was in large measure a continuation of studies previously begun by the Industrial Farm Products Research Division on the chemical conversion of oleic acid and naturally occurring and synthetic esters of oleic and other fatty acids into products industrially useful as wetting-out or emulsifying agents, fat-splitting agents, and lubricant-improving agents. Considerable attention was given to the possibility of preventing rancidification in lard by the use of nontoxic antioxidants. Attempts were made to synthesize some new fat-soluble antioxidants suitable for this purpose.

During the latter part of the year the principal activity of the Oil and Fat Division of the Eastern Regional Research Laboratory, undertaken at the request of the Chemical Warfare Service, was a search for a surface-active agent which would improve the penetrating power of solutions used to remove mustard gas from clothing and other articles of military equipment. Tentative selections of a few from a very large number of commercial wetting-out, penetrating, and emulsifying agents offered for use by the textile industry have been made, but final tests have not yet been completed.

TANNING MATERIALS, HIDES AND SKINS, AND LEATHER

The work on tanning materials, hides and skins, and leather is a continuation of projects of the former Industrial Farm Products Research Division which were transferred to the Eastern Regional Research Laboratory at the beginning of the fiscal year. It has been carried on in Washington pending completion of the pilot wing of the laboratory, into which actual moving was scheduled for September 1941.

Research has been continued on plant sources of new tanning materials, partly in cooperation with the Bureau of Plant Industry and the Soil Conservation Service. As crop possibilities, canaigre, a dock of the southwestern States and Mexico, having roots high in tannin, and also several native species of sumac which have leaves rich in tannin, are receiving special attention.

In the southeastern States trial plantings of canaigre have failed so far to give promising yields. Better results have been obtained in New Mexico and Texas, where enlarged plantings have been made for progeny, spacing, and yield studies. Preliminary observations indicate that in suitable locations irrigated crops of canaigre from selected strains may yield from 10 to 16 tons of fresh roots per acre, which roots contain about 22 percent tannin on the dry basis. Laboratory studies are in progress on making canaigre tanning extracts of both high and low purity.

Studies on sumac propagation from seed and rootstock are in progress. One plot from seed has yielded consistently less tannin than wild plants of the same species. However, another plot from seed sown in a different location had in the second year a tannin content equal to that of wild plants. Thus, it seems growing sumac from seed may be feasible under some conditions. Data on the tannin content of native sumacs are being acquired from an extensive collection of samples from eastern and southern States.

Other materials examined as part of the search for new sources of tannin included 26 samples of Chinese chestnut wood from trees 15 years old, 15 samples of domestic Acacia barks, 7 tung-nut hulls, and 3 of bark of young Kamachile trees growing in Florida.

A 5-year study on the effect of prolonged cold storage on salted calfskins was completed. Strictly comparable lots of leather made at yearly intervals from the stored skins showed no significant changes in the raw stock over the entire period.

From laboratory tests of the efficacy of 40 different formulas for curing hides and skins, the best preservation was obtained with various combinations of salt and sodium silicofluoride, para-nitrophenol, sodium tri- and penta-chlorphenates, beta-naphthol, sodium fluoride, sodium acid fluoride and N-N′-dichloroazodicarbonamidine.

In continued collaboration with the Government Printing Office 20 deliveries of combination vegetable- and chrome-tanned leathers for public binding work were subjected to accelerated aging and evaluated for probable durability.

Because of greatly increased purchases of leather goods by the Government, especially for its military forces, many technical questions have arisen with regard to Federal specifications. Through membership on the Committee on Leather, assistance has been given in the revision of existing specifications for harness, sole, belting, and lace leathers.

AGRICULTURAL ENGINEERING INVESTIGATIONS

The agricultural engineering studies embrace research in farm structures, such as the design and construction of farmhouses and other farm buildings, the storage of grain and other crops, and the construction requirements of silos; farm mechanical equipment, including that for pest control, fertilizer distribution, and crop handling; the farm processing of agricultural products, such as cotton and flax; and the use of electricity on the farm. Much of the work in agricultural engineering is carried on in cooperation with State agricultural experiment stations and other State agencies.

FARMHOUSE RESEARCH

Studies of comfort factors in farmhouses in Wisconsin, carried on in cooperation with the University of Wisconsin, showed that temperature stratification between floors and ceilings causes more discomfort in winter than any other factor. The difference between temperatures at floor and breathing height in a few instances averaged as much as 30° F. Heating engineers have studied various types of heating units in attempting to overcome the stratification tendency, but these studies indicate that the heat-transmission and infiltration characteristics of the building itself are of greater importance. Average reductions in stratification of 72 percent were made by using storm sash, weather stripping, and insulation to reduce heat losses. In houses of ordinary construction the types of heating systems commonly used in the northern States had little effect on stratification.

The investigations also showed that, in addition to greatly increasing comfort, these improvements resulted in reductions in fuel consumption of from 14 percent to over 50 percent in six farmhouses

in which records were kept. Such savings pay for the cost of improvements within a comparatively short time and in addition are of considerable importance at a time when the reduction in the consumption of all types of fuel is highly desirable.

These studies also showed how considerable savings in commercial building products involving processing and transportation can be made in rural areas through the use of native materials produced by the farm and processed by farm labor.

Further results have been obtained from continued studies of farmhouse comfort and economy factors in experimental houses at Athens, Ga., where the Bureau is cooperating with engineers of the University of Georgia. Here experiments showed that in houses as commonly constructed in the South, fuel consumption increased by as much as 56 percent with an increase of from 3 to 9.7 miles per hour in wind velocity. This indicated definitely the need for tightening houses to reduce infiltration, and further tests showed that by calking all cracks between the siding and around doors and window frames, and weather stripping windows, fuel savings of as much as 30 percent were possible. Additional savings of from 12 to 20 percent resulted from the use of curtain walls built between foundation piers. When, in addition to these improvements, the ceiling of the test house was insulated with 3⅝ inches of cottonseed hulls, a total fuel saving of about 48 percent was recorded.

In the winter tests much more uniform temperatures were observed when the houses had concrete-slab floors laid directly on well-drained ground instead of wood floors supported on piers. While the heat loss in winter is less through the concrete floor such floors also cool more slowly on summer nights, and it is, therefore, desirable to keep the sun from striking them.

It has been found difficult to promote summer comfort in low-cost houses so long as solar radiation is permitted to enter freely through windows and doors. Ordinarily window shades were found to reduce the daytime average air temperature from 3° to 4° F. Preliminary tests indicate that slatted blinds on the outside of windows and doors are even more effective than inside shades and have the added advantage of letting in more air. There was no appreciable difference in air or surface temperatures in houses having 8-foot and 10-foot ceilings, indicating that the conventional high ceiling used in the South is not a comfort factor. Tests are being made to determine the comfort value of shading walls and roofs with vines and trees.

In studies designed to determine the value of local materials for house insulation, cottonseed hulls have given promising results. A layer of hulls 3⅝ inches thick on the ceiling reduced fuel consumption from 16 to 25 percent, depending on infiltration through the walls and heat loss through floors. Some progress has been made in treating the hulls to make them resistant to fire, insects, and decay. Ammonium sulfate so far seems the most promising material for the purpose, but treatment with it is not entirely effective.

The farmhouse studies have led the Bureau to consider measures for providing sanitary and efficient plumbing at reasonable cost. To this end and to assist in bringing about more uniformity in plumbing codes, it has collaborated with the National Bureau of Standards through the Central Housing Committee in the prepara-

tion of a Plumbing Manual published as Building Materials and Structures Report 66 of the National Bureau of Standards. The Bureau also prepared a report covering engineering phases of building construction using various forms of earth, such as adobe, rammed earth, etc., the report to be used in connection with structural-strength tests made by the National Bureau of Standards of different types of earth walls.

BUILDINGS FOR LIVESTOCK

Because of the importance of good lighting in dairy barns, studies were made to determine the most satisfactory sizes and arrangement of lamps for efficiency and economy. The results, obtained in lighting dairies, show that the same lamps are more efficient if walls and ceilings are painted a light color and kept clean. Different kinds of lights were used, hung 26 inches below a 9-foot ceiling. At a distance of 5 feet a gas lantern of two-mantle type gave about the same illumination (2½ foot-candles) as a 100-watt electric lamp, and a common farm kerosene lantern with a ⅞-inch wick gave only one-tenth as much light. Electric lamps of 60 and 40 watts gave 1¾ and ¾ foot-candles at the same distance. Six fluorescent lamps of 40-watts gave about the same light at the milking level as six 100-watt Mazda lamps in the same positions, and the light was more pleasing. These fluorescent lamps were used for a year, giving 1,000 to 1,100 hours of service before failure. Improvements in starting devices for use in very cold weather and covering to protect against corrosive gases often found in stables should make them desirable for this use if present installation costs can be reduced. The 1½ to 2 foot-candles of light that milkers find desirable can be provided by placing ordinary 60-watt bulbs to the rear of every fourth cow, those for one row of cows staggered with those for the opposite row.

Research on the design and construction of hog houses has resulted in information that makes it possible for farmers to build better and more sanitary houses to fit the hog rather than forcing the animal to fit himself to the house. In cooperation with the Bureau of Animal Industry the Bureau has incorporated this information in a revision of Farmers' Bulletin 1487, Practical Hog Houses.

In line with the Department's effort to increase the production of poultry and poultry products as a part of the defense program, the Bureau has compiled a comprehensive bibliography on various phases of poultry housing.

SILAGE-PRESSURE STUDIES

A better understanding of structural requirements in silos used for storing grass silage is possible as a result of cooperative studies by the Bureau and the New Jersey Agricultural Experiment Station. The results show much higher pressures are produced by the grass silage than by the usual corn silage. For instance, corn silage having from 68 to 72 percent moisture in silos 40 feet deep and 14 feet in diameter, produced pressures at the bottom of the wall of 320 to 400 pounds a square foot; that with 81 percent moisture in 16-foot silos produced pressure as high as 900 pounds a square foot; that with 74 percent moisture in 18-foot silos gave pressures of 570 pounds.

But grass silage with moisture from 61 to 78 percent in 12-, 14-, and 18-foot silos, 40 feet deep, produced pressures from 320 to 1,200 pounds. Results show that grass silage made with an admixture of molasses always produces a higher pressure than that made with acid or put up plain. Data from these investigations have been published in the form of curves and tables showing the pressures upon which safe and economical silo design should be based.

POTATO STORAGES

The outstanding accomplishment in the recent studies of problems in storage of farm products is the development of the so-called shell-cooled potato bin, in which the air used in cooling is circulated around the whole mass of potatoes rather than through or over the pile. The new method, through better control of temperature and moisture, reduces potato losses from shrinkage and rotting, requires less attention than old methods, and should reduce the rate of deterioration of the structure. The economic importance of these results is emphasized by recent crop figures which show that each year about 200 million bushels of late-crop white potatoes, having a farm value of 150 million dollars, are placed in air storages where shrinkage and spoilage reduce the value by 1.5 million dollars. The storage buildings for these potatoes are worth about 50 million dollars and depreciation on them is estimated at about 2 million dollars a year.

CORN STORAGE

New types of circular steel cribs for storing ear corn were tested in Iowa and marked differences in performance were found. The moisture content of the corn in a 500-bushel crib with a perforated floor and a wind-suction ventilator decreased near the bottom, but increased in the middle and upper layers during the first few months of storage. Some drying occurred in the middle and upper layers in the spring, but not enough to prevent deterioration of the corn. On the other hand, a 500-bushel crib with wind-pressure ventilation dried the corn uniformly and rapidly throughout the mass. The corn in the critical central part of this crib dried more rapidly than that in the critical part of a rectangular crib of the same capacity and only 6½ feet wide. The corn in a 1,000-bushel pressure-ventilated steel crib 18 feet in diameter also dried as rapidly as that in the other cribs provided with more than the usual ventilation.

Field-harvested or "combined" shelled corn of rather high moisture content (17.5 to 21 percent) did not keep well in the experimental wind-pressure ventilated bins although this type of storage has proved successful in the storage of high-moisture grain in the chief wheat and grain sorghum areas. The limitations to the use of this type of ventilation for shelled corn in the Corn Belt are still to be determined.

Daily observations of moisture changes in individual ears of corn exposed to freely circulating outside air have shown that the moisture content fluctuates widely because of changes in hygrometric conditions of the air. In July 1940 the moisture content of the kernels was only 11 percent, but during a rainy period late in August it was 16.5 percent. Tests over the past 3 years have shown that the moisture content of ears so exposed has been lowest about the middle of May.

Large-scale studies have been made periodically of dry shelled corn in storage on farms and in steel bins owned by the Commodity Credit Corporation. This was a part of the grain-storage research carried on with Bankhead-Jones funds which included studies of wheat and grain sorghum in farm storage. The shelled-corn studies also included inspections of other bins where storage difficulties had been reported. The Bureau observations indicate that generally the dry shelled corn kept well except for damage by insects that commonly attack stored grain. In fall and winter there was an increase of moisture in the surface layer, but this dried quickly with no appreciable deterioration. In turning and cleaning shelled corn stored in Commodity Credit Corporation steel bins some damaged corn was found at the lower edges of the walls and on the floor resulting from entrance of moisture. This emphasizes the importance of having bin walls and floors tight to keep out moisture even in the form of vapor.

Observations of moisture damage to stored ear corn with excess moisture in certain areas of the Corn Belt in the fall of 1940 showed great differences in spoilage in different types of cribs. The single rectangular cribs well exposed had the least damage. The corn in octagonal cribs, with diameters of 14 to 16 feet, suffered the greatest damage.

Tests of moisture content of kernels and cobs in thousands of ear samples from farms in 84 Iowa counties have provided some basis for classifying parts of the State as to relative seriousness of corn-storage difficulties. The observations show the highest moisture content of the corn in the northeastern counties and the lowest in the northwestern for the entire 6-week period of sampling beginning the first of October. Where the moisture content of the kernels ranged from 18 to 35 percent, the moisture content of the cobs was nearly twice as much. This is a significant fact since most moisture determinations have been of the kernels only. Even if ear corn when cribbed has kernel moisture of 20.5 percent, which has been set as the maximum to be eligible for Government loans in cribs of recommended widths, the kernels may take up moisture from the cobs, especially in the more poorly ventilated parts of the crib.

WHEAT STORAGE

The successful farm storage of wheat for periods longer than 1 year would seem practicable from the results obtained so far in cooperative tests in Kansas, North Dakota, Illinois, and Maryland. Even wheat, much of which was originally above the commonly accepted safe moisture content, has been kept in good condition in ventilated bins at each of the four locations for periods of 1 to 4 years.

Aside from insect infestation, wheat moisture content and temperature are the principal factors to be controlled. Both bin ventilating systems and drying machines were found to be of value in this respect. Ventilated bins at all stations stored wheat safely at a higher moisture content than could be stored in an unventilated bin of the same size. In North Dakota a ventilated bin having a wind-pressure cowl forcing air into a central drum and through the wheat to perforated bin walls and floor, and upper wheat surface, was

more effective in storing wheat with an initial moisture content of 15.8 percent than were unventilated bins in storing 14.2 percent wheat. Final spoilage of the wheat was caused by snow entering the duct system. Similar differences between ventilated and unventilated bins were observed in the other States.

Because of differences in air temperatures and relative humidities, and farming practices, safe storage was shown to depend to a considerable extent upon geographical location. As the agricultural trend in the South is toward greater diversification, with more emphasis on the production of small grain, it would seem desirable to determine the best designs of wheat storage structures for this area that could be made of local materials and that could be ventilated and also fumigated.

GRAIN-SORGHUM STORAGE

Test results on storages for grain sorghum of high moisture content emphasize the value of special construction to make ventilation effective. Grain sorghum, stored in a 500-bushel tight bin, heated and spoiled after 6 months. A bin of the same size having perforated walls and an 18-inch perforated central flue open at the top and bottom, but not connected with a wind cowl, kept the grain better but not very well. One 1,000-bushel bin, with a perforated bottom and a wind-pressure cowl connected with a space under the bin bottom so as to move air up through the entire 8 feet of grain, had spoiled grain at the top after 6 months. In another 1,000-bushel bin having grain with the same moisture content as all the others an 18-inch wind cowl forced air down a vertical flue into a perforated chamber in the center of the bin from which it escaped through the grain in all directions—upward to the surface, outward through the perforated walls, and downward through the perforated floor. In this bin the moisture content was reduced to a safe level in 7 months. This type of bin is likely to find wider use.

PEST-CONTROL EQUIPMENT

Critical studies of multiple-nozzle commercial crop dusters brought out, among other things, extreme variations in the rate of delivery of insecticides and fungicides from the different nozzles. Some nozzles were found to deliver up to 400 percent more than others. It was also discovered that there was great variation in the tendency of the poison constituents to separate from the inert materials used as diluents. The various dust mixtures tested ranged in weight from 9 to 67.5 pounds per cubic foot. As a result of these studies the manufacturers of dusting equipment and of poison dusts have begun to improve their products. General use of better machines and materials would reduce costs and increase the effectiveness of crop pest control.

For spraying sweet corn to control the destructive European corn borer, the Bureau engineers devised and developed a machine with high-ground clearance. This machine, with the solid cone-type nozzles found most effective in applying the spray at the point of ear formation, promises better control of this widely distributed pest.

FERTILIZER-DISTRIBUTING MACHINERY

Continuing the study of fertilizer-distributing machinery and the proper placement of fertilizer to suit the needs of various plants and conditions, field experiments were conducted with 15 crops in 11 States, the Bureau cooperating with the Bureau of Plant Industry and the State experiment stations. Placement of the fertilizer immediately under the seed or transplant, a common practice, was found to be hazardous with most crops under usual conditions. An interesting exception developed in the case of superphosphate, which was found to benefit the crop more when placed under or around the seed in some cases when the more soluble ingredients of the complete fertilizer were properly placed to avoid injury.

Placement in a band at the side of the row of seed or transplants, the investigators found, is the most effective method of applying either complete fertilizer mixtures or readily soluble salts in appreciable amounts under the prevailing practices. The use of a nutrient starter solution or a supplementary treatment for transplanted crops, especially tomatoes, hastened the recovery of the plants and maturity of the crop in tests carried on in New York State. Localized application of superphosphate near the hill of cottonseed, compared with wider incorporation of this material in the soil, gave higher yields, mainly because less of the phosphate becomes fixed in the soil.

Field tests of the walking-type fertilizer distributors, commonly used in the South for cotton, shows that they do not fully meet the requirements for profitable fertilization. The results indicate that these machines can be improved through comparatively inexpensive and simple changes.

During the year the Bureau designed and constructed three new machines for distributing fertilizer—a drill for cannery peas, a small distributor for operation in a plow furrow, and a combination cultivator-distributor for applying the fertilizer as a side dressing to crops.

CROP-PRODUCTION MACHINERY

Last year the Bureau reported that a new device for planting sugar-beet seed, known as a single-seed-ball planter, saved from 10 to 20 percent of the usual seed requirement and noticeably reduced the labor needed in thinning the plants. This year, as the result of a newly devised method of splitting the seed balls into single-germ portions, further progress has been made in conserving seed and labor. The machine for splitting the seed consists basically of a commercial grinding wheel adapted to tear the seeds apart at the shear planes. The plantings in the spring of 1941, as a result of this new equipment and method, were made with only 2½ pounds of seed per acre as compared with the usual 20 pounds, and the stand of plants obtained was good.

Engineers on the sugar-beet project have made progress in solving the problem, of topping beets mechanically by developing a variable-cut unit equipped with a vibrating knife. They have also developed a vibrating beet lifter which in preliminary tests has proved satisfactory. To reduce drudgery in loading beets from the ground the experimenters have built a loader with a conveyor which carries the beets into trucks.

At the Bureau's Tillage Machinery Laboratory at Auburn, Ala., tests have shown that points of alloy steel on moldboard plows are good for one-third more service than similar plowshares fitted with carbon-steel points; that disks with the cutting edges beveled on the outside require from 18 to 25 percent more draft than disks having the cutting edge beveled on the inside; that notched and plain-edged disks differ somewhat in draft and soil penetration; and that moldboard plows may be made to shed sticky soil better by applying water in small quantities through a series of holes at the junction of the share and moldboard. These and the other results on tillage tools should be of considerable ultimate benefit to farmers as manufacturers incorporate these improvements in their designs.

As a result of investigations of corn-production machinery modifications were perfected in experimental equipment and technique for cultivating corn where cross cultivation is not practicable, as in farming on contours. Good control of weeds resulted without undue ridging of rows in surface-drill-planted corn.

Field tests of a subsoil-lister attachment for preparing the seedbed for corn showed a reduction of 32 percent in labor as compared with that needed when a plow was used. The plots prepared by the lister produced yields equal to those on the plots prepared by plowing. Improved husking rolls developed in the Bureau reduced the shelling loss of corn from 5.65 to 1.95 bushels an acre.

The manufacture of starch from the sweetpotato has led to a more thorough study of this crop from various standpoints, including growing and harvesting. Experiments have shown that deep plowing and bedding are more satisfactory in starting a crop than the shallow seedbed preparation common in the South. Side placement of fertilizer at time of transplanting resulted in higher yields than were obtained by the old methods, and wider spacings between the rows brought a greater quantity of large potatoes, which are cheaper to harvest and to process at the starch mills. To reduce the labor peaks in producing and handling this crop several machines have been devised, including a two-row machine for bedding, fertilizing, and transplanting, a low-cost digger, and a modified digger equipped with a truck-loading attachment. Exploratory studies indicate that by mechanization the cost of producing a sweetpotato crop can be greatly reduced.

Preliminary studies were made of present practices and equipment for collecting and packaging crop residues as a part of the effort to make so-called farm waste such as straws and stalks available cheaply for industrial utilization. Arrangements have been made with several agricultural experiment stations in the Middle West to make cost studies of this nature.

The Bureau, in cooperation with the New Jersey Agricultural Experiment Station, continued its studies of harvesting and handling grass crops for silage. Interest in the use of this feed has increased greatly in recent years and the Bureau is not only studying the machinery needed but also the special structural requirements of silos used for this purpose.

GINNING AND PACKING COTTON

The one element in the cotton industry with which cotton growers have intimate contact, and upon which they are increasingly depend-

ing for associated services, is ginning. In this country ginning has changed from a simple farm procedure to a specialized business venture. Many factors in cotton-ginning processes that have long interfered with maximum returns to growers and ginners or have injured the natural quality of the fiber have been gradually improved or eliminated since the establishment of the United States Cotton Ginning Laboratory in 1930. The past year's work in furtherance of these broader objectives has achieved success in developing better methods and equipment and in getting them adopted in representative commercial gins at many locations in the Cotton Belt.

The improvement of the quality and yield of cotton fiber through wider use of better varieties has led to a demand for better ways and equipment for handling seed at the gin so as to prevent mixing of different lots and at the same time avoid excessive handling costs. Among the improvements promoted by the Laboratory in preserving the purity of cotton seed at the gin has been the system of seed handling by means of a rotary low-pressure blower with 4-inch or 5-inch delivery pipes which are self-cleaning and which reduce by one-half the cost of handling as compared to conventional equipment.

The growing of long-staple American-Egyptian cotton is increasing rapidly, hence the Laboratory has devoted considerable time to improving roller ginning machinery, the kind needed to gin this type of cotton satisfactorily. The Laboratory has discovered a number of changes which speed up the rate of ginning, and it has shown that in the irrigated sections of the Cotton Belt the use of extractor-cleaner-feeders may improve this long staple from ½ to 2 grades. A new self-grooving roller developed for these gins has many advantages and appears to be more economical than the old-type rollers. A new lint doffer, also developed by the Laboratory staff, increases the efficiency of roller ginning and adds smoothness to the lint.

In the Southwest, where this American-Egyptian type is grown, there has been much ginning difficulty because of the creation of static electricity in the gins, and research to solve the problem is continuing.

A number of other ginning improvements are in prospect. Several years ago an instrument for determining the percentage of moisture in seed cotton was perfected by the Laboratory. Now another instrument is being developed to obtain similar information on the ginned lint. The latter instrument should permit pressing to be done to better advantage just as the tester for seed cotton makes possible better ginning.

Work is also under way to adapt cleaning equipment now used in cotton textile mills to additional cleaning of cotton at gins between the ginning and baling stages. A successful and economical means of doing this additional cleaning would raise grades and consequently increase the farmer's return.

The Bureau and the Agricultural Marketing Service, under which the Cotton Ginning Laboratory is operated jointly, are producing valuable results for farmers, ginners, and the industry as a whole. During the past year surveys have shown that more than 11 percent of the United States gins are now using the seed-cotton drying process developed by the Laboratory; 4.3 percent have made new installations of gins; 14 percent have adopted improved saws of the type the Laboratory has found best; 8.5 percent have reconditioned their saws; 4.6

percent have speeded up saws as recommended by the Laboratory; 2.1 percent had put in new gin fronts; 3.5 percent had put in new ribs; and about 25 percent have made major repairs and improvements recommended by the Laboratory.

Still further to improve the returns from cotton, the Laboratory has been carrying on studies with special research funds (Bankhead-Jones) on better ways of packaging cotton and on methods and equipment for obtaining greater density of cotton bales at gins where it may materially assist economical storage or shipment. During the fiscal year 1941, about 200 bales of cotton of different staple lengths and conditions were ginned and compressed in different types of presses. The investigators concluded that compressing with any of these presses did not materially affect the grade of staple either of the dried or undried cotton, and that after 4 months of storage cotton of low moisture content had usually gained weight while green and damp cottons in most cases had lost moisture.

In the packaging studies bales were covered with different kinds of bagging such as jute, cotton, burlap, and twill of various weights and mesh. Indications are that cotton bagging is withstanding weathering better than any of the other baggings. The use of cotton bagging provides a bale of neater appearance, and fewer breaks and tears appear in the bagging during the process of recompression at the compress. Furthermore, cotton bagging affords better protection to the bale contents from the standpoint of handling, recompression, and shipping.

Tests of different kinds of bale ties indicate that No. 9 gage wire may, if necessary, be used within certain limitations as a substitute for the conventional strap-iron ties.

In the bale-identification and weathering tests an attempt was made to find a marking ink that would reduce the loss from stain damage to the cotton. So far, the results indicate that a casein-base ink serves well for marking and leaves no permanent stain.

In the studies to develop equipment for producing greater bale densities at the gin, the investigators found that when the standard-density press box is reduced in width from 27 to 20 inches there is a good possibility that cotton can be pressed to a density of 25 pounds per cubic foot with the conventional gin pumps and with slight increase in power. This gives promise of a rather simple way to make large savings in shipping space and to reduce losses between the gin and the mill.

FIBER-FLAX PROCESSING

When the Bureau began work on fiber flax in 1938 the growing of the crop in this country was limited to a few thousand acres in Oregon and returns, both to growers and processors, were meager. The industry was using European methods and machinery. The Bureau has been studying basic principles underlying both methods and equipment with the idea of improving them to conform with American needs. During the course of the investigations almost every operation has been improved. A patent application has also been filed on an improved flax deseeder.

To facilitate the removal of the woody portion of the flax straw from the fiber, one of the most difficult and expensive of the flax-processing operations, the Bureau has developed a combined scutcher

and breaker, both units of which are quite different from conventional designs. The experimental results indicate the possibility of greatly increasing the yield of fiber over that obtained by the machines in general use.

Tests have been made to determine the feasibility of disposing of the water used in retting flax by using it for crop irrigation instead of piping it into streams where it is commonly considered a nuisance. It was found that when the water comes in contact with grass or other plants they will be killed but the plant growth the succeeding year is abundant, indicating that the waste water has some value as fertilizer. As a result of the various tests the Bureau has concluded that the most practical way of disposing of retting water waste, if it cannot be run into a river, is to provide two 8- or 10-acre ponds for each processing plant and to use them in alternating years, the intervening years being used for crops on the pond areas.

The war in Europe has practically shut off imports of flax fiber, and the price of domestic flax has increased greatly. The fiber-flax acreage in Oregon in 1941 also increased, more than 9,000 acres being planted. Each of the four existing flax mills has increased its capacity, and two new mills were completed for handling the 1941 crop.

The machines and improved methods developed during the course of this research project are valuable in themselves, but probably their greatest value is in strengthening thought and action in connection with flax-milling machinery and operations. Local machinery manufacturers are beginning to make flax-handling machines, and with better prices this new American industry has an encouraging prospect.

USES FOR ELECTRICITY IN FARMING

With the steady increase in the number of farms using electricity, profitable uses for current are of high importance. The Bureau is investigating various farm activities that might utilize electrical equipment.

In an effort to improve the quality of eggs, large numbers of which are retained on the farm or in receiving stations for several days before being shipped, the Bureau has studied the problem of developing economical coolers to prevent the drop in grade which causes many farmers to lose from 1 cent to several cents on the price of each dozen eggs.

Experiments conducted in cooperation with the Virginia and Indiana experiment stations on the short- and long-time holding of eggs have given promising results. In the short-time holding tests three different principles of cooling were used—ice, evaporation of water, and brine circulated through coils. The results of these tests are reflected in the following prices per dozen received on the Washington market:

	Cents
Held at room temperature and under normal conditions	24.84
Cooled with ice	26.76
Cooled by evaporation of water	27.24
Cooled by circulating brine	28.08

The ice cooling brought a net saving of 7.1 cents a case, cooling by evaporation of water brought a net saving of 59.8 cents a case, and

cooling by circulating brine brought a net saving of 67.25 cents a case. All tests showed that relative humidity is an important factor in maintaining egg quality. Results of tests on the long-time holding showed than when the average relative humidity dropped from 70.5 to 66.75 percent the percentage of Grade A eggs remaining at the end of 6 weeks' storage dropped from 78.9 percent to 40 percent.

Studies in the brooding of chicks, carried on cooperatively with the University of Georgia, showed conclusively that outdoor brooders are practicable in that region. It was found that heat may be supplied with kerosene-burning heaters at a slightly lower cash outlay than by electricity at current rates, but the work and fire hazards associated with the use of kerosene are considerably greater.

Tests made in cooperation with the University of Nebraska showed if the brooding units are made less than 3 feet wide the carbon dioxide concentration under the electrically heated hover will be less than 1 percent and that no provision need be made for forced ventilation.

The use of infrared radiation was tried for heat brooders but was not found as economical as the conventional method of supplying heat with electric heaters.

Electric heating of farrowing pens, tried out on 47 litters, reduced loss of pigs and increased rate of growth. Of 299 pigs farrowed alive in electrically heated houses, 245, or 82 percent, were alive at weaning time. Of 133 farrowed alive in unheated houses, 94, or 70.7 percent were alive at weaning time. The rate of growth was considerably greater in the pigs in heated pens. The electricity used during the period up to weaning was 27 kilowatt-hours per litter.

A low-power electric crosscut saw was designed in the Bureau for cutting fuel wood on the farm. With this device a ¼-horsepower electric motor substitutes for one man. The man operating the saw has some time for splitting wood while the saw is working. A set of plans for home construction of such a saw has been made available.

Investigations of the effect of warming stock water in winter for 40 yearling steers who had free access to both warmed and ice-cold water showed that they consumed approximately 50 percent more of the cold water, except during one extremely cold period when they used nearly three times as much warmed water as they did cold.

Farmers' Bulletin No. 1858, Electric Motors for the Farm, was made available for distribution during the latter part of the year.

INFORMATION AND PUBLICATIONS

The Bureau published 4 Technical Bulletins, 7 Circulars, 1 new and 1 revised Miscellaneous Publications, 4 Farmers' Bulletins, 4 articles in the Journal of Agricultural Research, 1 Yearbook article, 1 article in Extension Service Review, 1 annual report, 52 mimeographed publications, and 176 articles in outside journals and proceedings. The Bureau also furnished information on various phases of its research through the press and radio services of the Department and made a number of displays at exhibits.

Seven patents were issued to scientists of the Bureau during the year.

The following lists show the publications and patents resulting from the research work of the Bureau:

LIST OF PUBLICATIONS

AGRICULTURAL CHEMICAL INVESTIGATIONS

Citrus fruit products. By E. M. Chace, H. W. von Loesecke, and J. L. Heid. U. S. Dept. Agr. Cir. 577.

Determination of air in citrus juices. By H. J. Loeffler. Indus. and Engin. Chem., Analyt. Ed. 12: 533–534. 1940.

Manufacture and physical properties of grapefruit seed oil. By Arthur J. Nolte and Harry W. von Loesecke. Indus. and Engin. Chem. 32: 1244–1246. 1940.

Determination of peel oil in grapefruit juice. By W. C. Scott. Assoc. Off. Agr. Chem. Jour. 24: 165–170. 1941.

Chemical and physical characteristics of the petroleum ether soluble material of fresh and canned Florida Valencia orange juice. By Arthur J. Nolte and Harry W. von Loesecke. Food Res. 5: 457–467. 1940.

The fatty constituents of California Valencia orange pulp (*Citrus Aurantium sinensis* L.). By M. B. Matlack. Jour. Organic Chem. 5: 504–507. 1940.

Sauce preparation from Pacific Northwest apples. By A. M. Neubert and H. H. Mottern. Fruit Prod. Jour. and Amer. Vinegar Indus. 20 (3): 68–71, 89, and 92. 1940.

Canning apple juice in the Pacific Northwest. By H. H. Mottern, A. M. Neubert, and C. W. Eddy. Fruit Prod. Jour. and Amer Vinegar Indus. 20 (2): 36–38, 55, and 57. 1940.

Frozen locker storage developed here. By J. L. Heid. Mission Times 32 (16): 6–7. 1941.

Quality in frozen pack peas. By H. Campbell and H. C. Diehl. West. Canner and Packer 32 (10 and 11): 48–50, 51–53. 1940.

Some observations on the materials employed in packaging frozen foods. (Abstract.) By William Rabak. Paper Trade Jour. 3 (9): 80–82. 1940.

The scalding of cut corn for freezing. By Horace Campbell. West. Canner and Packer, Frozen Foods Recorder 32 (9): 51–53 and 55. 1940.

The splitting of shelled peas intended for freezing. By Horace Campbell. West. Canner and Packer Frozen Foods Recorder 32 (8): 49–50. 1940.

Quick freezing fruits and vegetables. By H. C. Diehl. Refrig. Engin. 2: 19–30. 1940.

The freezing preservation of citrus fruits and juices. By J. L. Heid. ACE–8. (Mimeographed.) 1941.

Preparing asbestos for filtering mats. By Ben L. Kaspin. Indus. and Engin. Chem., Analyt. Ed. 12: 517. 1940.

Eggs and egg products. A publication by poultry and egg specialists of the United States Department of Agriculture. U. S. Dept. Agr. Cir. 583.

Quality of frozen poultry as affected by storage and other conditions. By Harold M. Harshaw, Walter S. Hale, T. L. Swenson, Lucy M. Alexander, and R. R. Slocum. U. S. Dept. Agr. Tech. Bul. 768. (United States Department of Agriculture, Bureaus of Animal Industry, Agricultural Chemistry, and Engineering, and Home Economics and the Agricultural Marketing Service, in cooperation with the Institute of American Poultry Industries.)

Windrowing and storing of sugarcane in Louisiana following injury by freezing temperatures. By J. I. Lauritzen, Charles A. Fort, and R. T. Balch. U. S. Dept. Agr. Tech. Bul. 726. (With Bur. Plant Indus.)

Inversion of sucrose in the different parts of the sugarcane stalk. By J. I. Lauritzen and R. T. Balch. Jour. Agr. Res. 61: 1–16. 1940. (With Bur. Plant Indus.)

Containers for apple and other fruit juices pasteurized by the flash method. By C. S. Pederson, H. C. Beattie, and E. A. Beavens. Proc. Food Conf. Inst. Food Technol., pp. 205–211. June 16–19, 1940. (With N. Y. Agr. Expt. Sta.)

Preliminary report on the crystallization of sucrose from juices of the sorgo plant. By E. K. Ventre. Sugar Jour. 3 (7): 23–30. 1940. (Abstract in Facts About Sugar 36 (1): 36–37. 1941.)

Aconitic acid in sediment and scale in Louisiana sugar houses. By M. A. McCalip and A. H. Seibert. Sugar Bul. 19 (17): 84–87. 1941.

Aconitic acid from sugarcane products. By M. A. McCalip and Arthur H. Seibert. Indus. and Engin. Chem. 33: 637–640. 1941.

Rapid determination of starch (root) with sodium hypochlorite. By R. T. Balch. Indus. and Engin. Chem., Analyt. Ed. 13: 246–248. 1941.

Report of studies on uniformity of quality of sugars: Part I. Chemical studies of beet sugars collected during the 1940 campaign. By C. A. Fort, S. Byall, and R. M. Kingsbury. Part II. Biological studies on sugars of 1940 campaign. By H. H. Hall. ACE–103. (Mimeographed.) 1941.

Preliminary report on sugarcane wax. By R. T. Balch. ACE–99. (Mimeographed.) 1941.

Color standards for grading maple sirup. ACE–79. (Mimeographed.) 1941.

The cause of warp yarn breaks in weaving. (Abstract.) By Walter T. Schreiber. Cotton (Serving the Textile Indus.) 105 (6): 86–89 and 93. 1941.

Molecular distillation and low temperature crystallization of cottonseed oil and the stability of the molecularly distilled fractions. By R. W. Riemenschneider, C. E. Swift, and Charles E. Sando. Oil and Soap 17 (7): 145–148. 1940.

Tung oil remains industry's best drying oil. By Henry G. Knight. Mfrs. Rec. 110 (6): 34, 35, and 64. 1941.

A rapid method for the determination of oil in tung fruit. By R. S. McKinney and W. G. Rose. Oil and Soap 18 (2): 25–27. 1941.

Cocos Pulposa palm kernel oil. By G. S. Jamieson and W. G. Rose. Oil and Soap 17 (7): 144. 1940.

Isolation from *Astragalus pectinatus* of a crystalline amino acid complex containing selenium and sulfur. By Millard J. Horn and D. B. Jones. Jour. Biol. Chem. 139: 649–660. 1941.

The isolation of lanthionine from human hair, chicken feathers, and lactalbumin. By M. J. Horn and D. B. Jones. Jour. Biol. Chem. 139: 473. 1941.

The effects of heat on the nutritive value of proteins. Seed proteins of leguminous plants. By D. B. Jones. Jour. Nutrition 21 (6): 20–21 1941.

Isolation of a new sulfur-containing amino acid (lanthionine) from sodium carbonate-treated wool. By Millard J. Horn, D. Breese Jones, and S. J. Ringel. Jour. Biol. Chem. 138: 141–149. 1941.

Chemical and bacteriological changes in dill pickle brines during fermentation. By I. D. Jones, M. K. Veldhuis, J. L. Etchells, and Otto Veerhoff. Food Res. 5: 533–547. 1940. (With N. C. Agr. Expt. Sta.)

The incidence of yeasts in cucumber fermentations. By John L. Etchells. Food Res. 6: 95–104. 1941.

Observations on bloater formation in cucumber fermentation. By I. D. Jones, Otto Veerhoff, J. L. Etchells, and M. K. Veldhuis. Fruit Prod. Jour. and Amer. Vinegar Indus. 20: 202–206, and 219–220. 1941. (With N. C. Agr. Expt. Sta.)

Methods of examination of fresh cucumber pickle. By John L. Etchells and Harry E. Goresline. Fruit Prod. Jour. and Amer. Vinegar Indus. 19: 331–335. 1940.

The fermentation of ameliorated musts. By Harry E. Goresline, E. A. Beavens, and A. L. Curl. Fruit Prod. Jour. and Amer. Vinegar Indus. 20: 10–12. 1940.

Keeping quality of bottled wines—effect of head-space. By C. S. Pederson, Harry E. Goresline, A. L. Curl, and E. A. Beavens. Indus. and Engin. Chem. 33: 304–307. 1941. (With N. Y. Agr. Expt. Sta.)

Results of a demonstration sale of apple-raspberry juice. By Carl S. Pederson, H. G. Beattie, and E. A. Beavens. Fruit Prod. Jour. and Amer. Vinegar Indus. 20: 227–228 and 247. 1941. (With N. Y. Agr. Expt. Sta.)

Cherry juice and cherry beverages. By Donald K. Tressler, Carl S. Pederson, and E. Arthur Beavens. N. Y. Agr. Expt. Sta. Cir. 180. 1941. (With N. Y. Agr. Expt. Sta.)

The non-volatile acids of the potato. By A. L. Curl and E. K. Nelson. Amer. Potato Jour. 17: 328–330. 1940.

The determination and significance of phenols in vanilla extract. By A. K. Balls and Francisca E. Arana. Assoc. Off. Agr. Chem. Jour. 24: 507–512. 1941. (With Puerto Rico Agr. Expt. Sta.)

The effect of ethylene on freshly harvested wheat. By A. K. Balls and W. S. Hale. Cereal Chem. 17: 490–494. 1940.

The composition of certain nutshells. By Max Phillips and M. J. Goss. Assoc. Off. Agr. Chem. Jour. 23: 662–665. 1940.

Studies on phenothiazine. IX. The biliary excretion and anthelmintic action of thionol. By Floyd DeEds and John O. Thomas. Jour. Parasitol. 27: 143–151. 1941.

Studies on phenothiazine. X. Further observations on the oxidation of phenothiazine. By F. DeEds. Soc. Expt. Biol. and Med. Proc. 45: 632–634. 1940.

Effects of continued cadmium feeding. By Robert H. Wilson, Floyd DeEds, and Alvin J. Cox, Jr. Jour. Pharmacol. and Expt. Ther. 71: 222–235. 1941. (With Stanford Univ. School of Medicine, San Francisco, Calif.)

Experimental treatment of citrus cannery effluent in Florida. By H. W. von Loesecke, G. N. Pulley, Arthur J. Nolte, and H. E. Goresline. Sewage Works Jour. 13 (1): 115–131. 1941.

Sodium chlorate—cell design. By P. H. Groggins, A. L. Pitman, and F. H. Davis. Chem. & Metall. Engin. 47: 468–470. 1940.

The efficiency of a sodium chlorate cell with rod cathodes. By James McLaren, Jack Turner, F. H. Davis, A. L. Pitman, and P. H. Groggins. Electrochem. Soc. Trans. 79. Apr. 1941.

Pasteurization of genuine dill pickles. By J. L. Etchells, M. K. Veldhuis, I. D. Jones, and Otto Veerhoff. Fruit Prod. Jour. and Amer. Vinegar Indus. 20: 304–305, 316, and 325. 1941. (With N. C. Agr. Expt. Sta.)

Selected list of references on frozen and dried eggs. Bur. Agr. Chem. and Engin. (Mimeographed.) May 1941.

Egg storage. Bur. Agr. Chem. and Engin. Mimeographed.) May 1941.

INDUSTRIAL UTILIZATION OF FARM PRODUCTS AND BYPRODUCTS

Plastics from bagasse and other agricultural residues. By S. I. Aronovsky and T. F. Clark. Mfrs. Rec. 110 (3): 22–25 and 59. 1941.

Conductometric analysis of sodium sulphite and ammoniacal pulping liquors. By E. R. Whittemore, E. C. Dryden, and S. I. Aronovsky. Paper Trade Jour. 112 (25): 29–34. 1941.

A laboratory-size leaf-type pressure filter. By T. F. Clark, N. Porges, and S. I. Aronovsky. Indus. and Engin. Chem., Analyt. Ed. 12: 755–757. 1940.

Graphical correlation between pH values molarities, and dissociation constants of weak acids. By Nandor Porges and Thomas F. Clark. Jour. Chem. Ed. 17: 571–573. 1940.

NAVAL STORES INVESTIGATIONS

Turpentine still buildings and equipment. By the Naval Stores Res. Div. U. S. Dept. Agr. Misc. Pub. 387.

Jet condenser set-up for turpentine still. By E. L. Patton and R. A. Feagan. ACE–78. (Mimeographed.) 1941.

1940 semiannual naval stores report on production, distribution, consumption, and stocks of turpentine and rosin of the United States. By C. F. Speh. Naval Stores Rev. 50 (36): 6; ACE–70. (Mimeographed.) 1940.

1940–41 annual naval stores report on production, distribution, consumption, and stocks of turpentine and rosin of the United States. By C. F. Speh. Naval Stores Rev. 51 (10): 8, 10, 13, 16, and 20; ACE–92. (Mimeographed.) 1941.

The Naval Stores Research Division and the naval stores industry. By C. F. Speh. Gamble's Internatl. Naval Stores Yearbook, 1939–40, pp. 129–132. 1940.

Publications on production, properties, examination, marketing, and uses of naval stores. ACE–73. (Mimeographed.) 1940.

Some publications relating to production, properties, examination, marketing, and uses of naval stores. ACE–74. (Mimeographed.) 1940.

A study of the cost of production of naval stores. By Harry D. High. ACE–59. (Mimeographed.) 1940.

Rosin cleanliness. By G. P. Shingler and E. L. Patton. Naval Stores Rev. 50 (52): 8; Oil and Soap 18 (6): 133; Paint, Oil, and Chem. Rev. 103: 8. 1941.

Studies in the storage of turpentine gum for distillation. By G. P. Shingler. Naval Stores Rev. 51 (6): 13; ACE–89. (Mimeographed.) 1941.

Comparative summary of crude and cleaned gum distillation work at the Naval Stores Station, Olustee, Fla. By G. P. Shingler. Naval Stores Rev. 51 (5): 16; ACE–88. (Mimeographed.) 1941.

How to stop leaks from the side sampler in a metal rosin drum. By E. L. Patton. ACE–72. (Mimeographed.) 1941.

Tare weight of dip barrels. By H. D. High. Naval Stores Rev. 50 (39): 10. 1940; AT–FA Jour. 3: 4. 1941.

Avoid cracked still crowns. By John O. Boynton. Naval Stores Rev. 50 (35): 15; AT–FA Jour. 3 (3): 10. 1940.

Protect your still plant from fire. By John O. Boynton. Naval Stores Rev. 50 (36): 13; AT–FA Jour. 3 (3): 10. 1940.

Suggestions on gum buying. By John O. Boynton. Naval Stores Rev. 50 (31): 8. 1940.

Comments on gum buying and selling. By G. P. Shingler and H. D. High. Naval Stores Rev. 50 (47) : 8–13. 1941.

A comparison of the effects of slash and longleaf gums on cup materials. By Ray V. Lawrence. ACE–101. (Mimeographed.) 1941.

Composition of American gum turpentine exclusive of the pinenes. By T. C. Chadwick and S. Palkin. U. S. Dept. Agr. Tech. Bul. 749.

The work of the naval stores cooperative agents. By Naval Stores Research Division. Naval Stores Rev. 50 (21) : 8 and 13. 1940.

A hydrometer for turpentine indicating pounds per gallon. By W. C. Smith. Indus. and Engin. Chem. 13 : 112–114. 1941.

A hydroxy-lactone from d-pimaric acid. By E. E. Fleck and S. Palkin. Amer. Chem. Soc. Jour. 62 : 2044–2047. 1940.

Surface tension of rosin soap solution. By W. D. Pohle. Oil and Soap 17 (7) : 150–151. 1940.

Detergent action of rosin soaps and fatty acid-rosin soaps. By W. D. Pohle and C. F. Speh. Oil and Soap 17 (10) : 214–216. 1940.

The germicidal action of cleaning agents—a study of a modification of Price's procedure. By W. D. Pohle and L. S. Stuart. Jour. Infect. Dis. 67 : 275–281. 1940.

The germicidal activity of rosin soap and fatty acid-rosin soap as indicated by hand-washing experiments. By W. D. Pohle and L. S. Stuart. Oil and Soap 18 (1) : 2–7. 1941.

Germicidal activity of soaps. By L. S. Stuart and W. D. Pohle. Soap and Sanitary Chem. 17 (2 and 3) : 34–37 and 73–74. 1941.

SPECIAL RESEARCH IN AGRICULTURE

(Under Bankhead-Jones Act of June 29, 1935)

Observations on the sensitization of guinea pigs with alum-precipitated ragweed extract. By E. J. Coulson and Henry Stevens. Soc. Expt. Biol. and Med. 45 : 798–800. 1940.

Antigenic relationship of cotton linters, dust, and dust precursors. By E. J. Coulson and Henry Stevens. Jour. Allergy 11 : 537–556. 1940.

The chemistry of allergens. III. The solubility behavior of an active protein picrate from cottonseed. By Joseph R. Spies, Harry S. Bernton, and Henry Stevens. Amer. Chem. Soc. Jour. 62 : 2793–2799. 1940.

Recovery of the cottonseed allergenic protein from its picrate by electrophoresis. By Joseph R. Spies. Amer. Chem. Soc. Jour. 63 : 1166. 1941.

Autolysis in meat. (Abstract.) By A. K. Balls, G. Y. Gottschall, and M. W. Kies, Amer. Soc. Biol. Chem. Proc. 9 : 9–10. 1941.

Drying of papaya latex—stability of papain. By A. K. Balls, H. Lineweaver, and S. Schwimmer. Indus. and Engin. Chem. 32 : 1277–1279. 1940.

Crude papain. By A. K. Balls, R. R. Thompson, and W. W. Jones. Indus. and Engin. Chem. 32 : 1144–1147. 1940. (With Hawaiian Agr. Expt. Sta.)

Chymopapain : A new crystalline proteinase from papaya latex. By E. F. Jansen and A. K. Balls. Jour. Biol. Chem. 137 : 459–460. 1941.

A comparison of the action of crystalline papain on native and urea-denatured proteins. By Hans Lineweaver and S. R. Hoover. Jour. Biol. Chem. 137 : 325–335. 1941.

The reaction of formaldehyde with amino acids : X-ray diffraction patterns. By Allan K. Smith, Philip Handler, and John Niel Mrgudick. Jour. Phys. Chem. 44 : 874–880. 1940. (With Univ. Ill.)

The effect of formaldehyde on the isoelectric points of some proteins by microelectrophoresis. By Sidney J. Circle and Allan K. Smith. Jour. Phys. Chem. 45 : 916–930. 1941.

Soybean protein, resume and bibliography. By George H. Brother, Allan K. Smith, and Sidney J. Circle. ACE–62. (Mimeographed.) 1940.

A simple flexure testing machine for plastics. By G. H. Brother, W. C. Suttle, and L. L. McKinney. Amer. Soc. Testing Mater. Bul. 109 : 13–16. 1941.

Soybeans in plastics. Flow properties of a phenolic type plastic modified with formaldehyde-hardened soybean meal. By L. L. McKinney and G. H. Brother. Mod. Plastics 18 (9) : 69–71. 1941.

Protein plastics from soybean products. Laminated material. By George H. Brother, Leonard L. McKinney, and W. Carter Suttle. Indus. and Engin. Chem. 32 : 1648–1651. 1940.

Protein plastics from soybean products. Influence of phenolic resins or phenolic molding compounds on formaldehyde-hardened protein material. By George H. Brother and Leonard L. McKinney. Indus. and Engin. Chem. 32 : 1002–1006. 1940.

The stability of vegetable oils. I. The spectral transmittance of soybean oils. By W. G. Bickford, Scott Anderson, and K. S. Markley. Oil and Soap 17 (7) : 138–143. 1940.

The stability of vegetable oils. II. Apparatus for determination of the rate of fading of methylene blue-fat systems. By W. G. Bickford and K. S. Markley. Oil and Soap 17 (11) : 232–240. 1940.

The stability of vegetable oils. III. Investigation of the effect of radiation on the methylene blue-oil system. By W. G. Bickford, Scott Anderson, and K. S. Markley. Oil and Soap 17 (12) : 252–256. 1940.

The stability of vegetable oils. IV. Flavor reversion in soybean oil. By W. G. Bickford. Oil and Soap 18 (5) : 95–98. 1941.

Sterols from crude soybean oil. By H. R. Kraybill, M. H. Thornton, and K. E. Eldridge. Indus. and Engin. Chem. 32 : 1138–1139. 1940.

Sterol glucosides from expressed soybean oil. By M. H. Thornton, H. R. Kraybill, and J. H. Mitchell, Jr. Amer. Chem. Soc. Jour. 62 : 2006–2008. 1940.

The melting points of binary mixtures of oleic, linoleic, linolenic acids. By H. W. Stewart and D. H. Wheeler. Oil and Soap 18 (4) : 69–71. 1941.

Supplement to bibliography on molecular or short-path distillation. By S. B. Detwiler, Jr. Oil and Soap 17 (11) : 241–243. 1940.

Wax constituents of the winterizer press cake of soybean oil. By F. R. Earle and Samuel B. Detwiler, Jr. Oil and Soap 18 (6) : 117–119. 1941.

A method for the determination of nonprotein nitrogen in soybean meal. By H. C. Becker, R. T. Milner, and R. H. Nagel. Cereal Chem. 17 : 447–457. 1940.

Report of the soybean analysis committee. By T. H. Hopper. Oil and Soap 18 (6) : 132–133. 1941.

A study of the moisture in soybeans. By A. C. Beckel and F. R. Earle. Indus. and Engin. Chem., Analyt. Ed. 13 : 40–43. 1941.

Modern practice in solvent extraction. By W. H. Goss. Chem. & Metall. Engin. 48 (4) : 80–84. 1941.

U. S. Regional Soybean Industrial Products Laboratory. By R. T. Milner. Phi Lambda Upsilon Register 26 (1) : 6–14. 1941.

Soybean oil traffic paint probable. By R. T. Milner. Soybean Digest 1 (2) : 2. 1940.

Processing soybeans for oil and meal. ACE–71. (Mimeographed.) 1940.

Technological problems in processing soybeans. I. The continuous-pressing method. By W. H. Goss. Soybean Digest 1 (8) : 2–3. 1941.

News from the Regional Soybean Laboratory. By R. T. Milner. Proc. Amer. Soybean Assoc., pp. 36–38. 1941.

Grain storage on the farm. By Thomas E. Long and Myron G. Cropsey. N. Dak. Expt. Sta. Bul. 302 : 1–68. 1941. (With N. Dak. Agr. Expt. Sta.)

Research work in wheat storage. By C. F. Kelly. Agr. Engin. 21 :(12) 473–475. 1940.

Temperatures of wheat in experimental farm-type storages. By C. F. Kelly. U. S. Dept. Agr. Cir. 587.

REGIONAL RESEARCH LABORATORIES

The farm and the factory. By Henry G. Knight. Toledo Business 18 (8) : 17–18; New Mexico Today 1 (6) : 13–14; La-Crosse Business 6 (8) : 9–10. 1940.

The new farm research laboratories of the U. S. Department of Agriculture. By Henry G. Knight. Phi Lambda Upsilon Register 25 (4) : 104–108. 1940.

The research program on starch in the new regional laboratories. By Henry G. Knight. Amer. Assoc. Cereal Chem., News Letter 50 (2) : 1–5. 1940.

Regional laboratories progress report. By Henry G. Knight. ACE–86. (Mimeographed.) 1941.

Storage of crop fibers and preservation of their products. By Harold R. Hay and E. C. Lathrop. Paper Trade Jour. 112 (9) : 29–34. 1941.

Northern Regional Research Laboratory. By Joseph H. Shollenberger and Harry E. Roethe. Amer. Miller 69 (2) : 36–38; ACE–76. (Mimeographed.) 1941.

Fermentation of concentrated solutions of glucose to gluconic acid. By A. J. Moyer, E. J. Umberger, and J. J. Stubbs. Indus. and Engin. Chem. 32 : 1379–1383. 1940.

Ketogluconic acids from glucose. Bacterial production. By J. J. Stubbs, L. B. Lockwood, E. T. Roe, B. Tabenkin, and G. E. Ward. Indus. and Engin. Chem. 32 : 1626–1631. 1940.

The quest for new utilization of wheat. By J. H. Shollenberger. Southwest. Miller 19 (37) : 19 and 39. 1940.

Domestic utilization of cotton in relation to economic conditions in the South. By R. J. Cheatham. Jour. Home Econ. 32 : 447–451. 1940.

The importance of chemical finishing in increasing the consumption of cotton textiles. By Walter M. Scott. Jour. Home Econ. 32 : 451–454. 1940.

Cotton overcoats for sheep. By Southern Regional Research Laboratory. Cotton Trade Jour. 21 (1) : 1. 1941.

The fine structure of cellulose as revealed by x-ray and other methods. (Abstract.) By W. James Lyons. 88th Ann. Meeting New Orleans Acad. Sci., Mar. 27–29, 1941, p. 3.

Crystal density of native cellulose. By W. James Lyons. Jour. Chem. Phys. 9 : 377–378. 1941.

The technology of the cottonseed crushing industry. By K. S. Markley and D. F. J. Lynch. ACE–63. (Mimeographed.) 1940.

Trends in the consumption of fibers in the United States 1892–1939. By Robert B. Evans and Rose F. Monachino. ACE–93. (Multilithed.) 1941.

Leather. By R. W. Frey and J. G. Schnitzer. Britannica Book of the Year, pp. 398–399. 1941. (With Bur Foreign and Domestic Commerce.)

Apple juice, 1940 model. By Truman Nold, H. H. Mottern, and J. J. Willaman. Rpt. 7th Ann. Meeting Natl. Apple Inst., pp. 26–31. June 1941. (With Natl. Apple Inst.)

What else can we do with vegetables. By J. J. Willaman. Natl. Seedsman 7 (4) : 6–7 and 44. 1940.

Tobacco research in the Eastern Regional Research Laboratory. By E. G. Beinhart. Tobacco Leaf 77 (3982–3983) : 6 and 12. 1941.

Curing skins with salt containing sodium carbonate or sodium sulfate. By L. S. Stuart and R. W. Frey. Amer. Leather Chem. Assoc. Jour. 36 : 114–120. 1941.

Studies on the resalting of salt-cured calfskins. By L. S. Stuart. Amer. Leather Chem. Assoc. Jour. 35 : 554–562. 1940.

The permanence to acid deterioration of vegetable leather retanned with alum. By R. W. Frey and C. W. Beebe. Amer. Leather Chem. Assoc. Jour. 35 : 440–443. 1940.

Some aspects of humidity control in the storage of salt-cured calfskins. By L. S. Stuart and R. W. Frey. Amer. Leather Chem. Assoc. Jour. 35 : 432–439. 1940.

The growth of halophilic bacteria in concentrations of sodium chloride above three molar. By L. S. Stuart. Jour. Agr. Res. 61 : 259–266. 1940.

Effect of protein concentration and cysteine on growth of halophilic bacteria. By L. S. Stuart. Jour. Agr. Res. 61 : 267–276. 1940.

A program on the development of domestic tanning materials. By Ralph W. Frey and Arthur F. Sievers. Amer. Leather Chem. Assoc. Jour. 35 : 647–655. 1940. (With Pur. Plant Indus.)

The library of the Western Regional Research Laboratory. By W. Lawrence Shaw. Spec. Libr. Assoc., San Francisco Bay Chapter Bul. 11 (7) : 3–4. 1941.

Short biographical sketches of director and division chiefs of the Western Regional Research Laboratory. Vortex 11 (2) : 47–52. 1941.

Official and tentative methods of analysis. By Kenneth T. Williams. Cereal Chem. 18 : 266. 1941.

Poultry products research and the Western Regional Research Laboratory. By T. L. Swenson. Nulaid News 18 (11) : 16. 17, and 47 ; Washcoegg 18 (10) : 61–63. 1941.

The Western Regional Laboratory for research on utilization of farm products. By W. B. Van Arsdel. Calif. Dept. Agr. Bul. 30 (1) : 18–22. 1941.

Wheat and flour technology. By M. J. Blish. Fruit Prod. Jour. and Amer. Vinegar Indus. 20 : 296. 1941.

Review of "What are the vitamins? By Walter H. Eddy." By G. Ivor Jones. Cereal Chem. 18 : 413. 1941.

Freezing and storage of frozen pack fruits and vegetables. By H. C. Diehl and J. A. Berry. Assoc. Refrig. Warehouses Spec. Bul. 2 (12) : 1–7. 1941.

Technological aspects of locker plant industries. By H. C. Diehl. Quick Frozen Foods 3 (7 and 8) : 16–17, and 42 ; 24, and 37–38. 1941.

The industrial market for farm products. By W. B. Van Arsdel. U. S. Dept. Agr. Yearbook Sep. 1749.

AGRICULTURAL ENGINEERING INVESTIGATIONS

Foundations for farm buildings. By Thos. A. H. Miller and E. G. Molander. U. S. Dept. Agr. Farmers' Bul. 1869.

Closets and storage spaces. By Maud Wilson, J. Robert Dodge, and Elma Edwards. U. S. Dept. Agr. Farmers' Bul. 1865. (With Bur. Home Econ.)

Observations on the storage of grass silage. By H. E. Besley and J. R. McCalmont. Amer. Soc. Agr. Engin. 22 (2): 80, ACE–77. (Mimeographed.) 1941.

Needed research on southern farm buildings. By W. V. Hukill. Agr. Engin. 22 (4): 127–128. 1941.

Questions about southern farm buildings. By W. V. Hukill. ACE–80. (Mimeographed.) 1941.

New approaches to farmhouse design, construction, and equipment. By J. W. Simons. Agr. Engin. 22 (5): 181–184; ACE–82. (Mimeographed.) 1941.

Work and interests of the Bureau of Agricultural Chemistry and Engineering in rural housing. By Wallace Ashby. ACE–64. (Mimeographed.) 1940.

Co-operative relations and organized effort for farm building service. By Wallace Ashby. ACE–65. (Mimeographed.) 1940.

Errors, corrections, and a reprint of the northeast plan service. By T. A. H. Miller. ACE–66. (Mimeographed.) 1940.

Better homes for southern farmers. By A. C. Hudson. ACE–105. (Mimeographed.) 1941.

Refrigeration has many uses in the laboratory. By John T. Bowen and W. V. Hukill. Refrig. Engin. 40: 287–291 and 305. 1940.

Management of potato storages. By M. G. Cropsey, Jr. N. Dak. Agr. Col. Ext. Cir. 170, p. 8. 1940.

9,000,000 bushels of potatoes. By M. G. Cropsey, Jr. Bison Furrows 4 (2): 5 and 15. 1940.

One hundred years of farmhousing. By J. R. Dodge. South. Planter 11: 4, 18–19. 1940.

Today's farm home. By J. W. Simons. South. Agr. 70 (7): 6 and 7. 1940.

Their home kept step for 60 years. By O. E. Brunkow and Max J. LaRock. Successful Farming 39 (2): 18–19 and 72. 1941. (With Univ. Wis.)

Domestic oil burner efficiency graph. By Arthur H. Senner. Air Conditioning and Oil Heat 14 (6): 12–13. 1941.

Farmhouse research in Wisconsin. By J. Robert Dodge. U. S. Ext. Serv., Ext. Serv. Rev. 2 (8): 103. 1940.

Calorimetric measurements of the heat of respiration of fruits and vegetables. By W. P. Green, W. V. Hukill, and D. H. Rose. U. S. Dept. Agr. Tech. Bul. 771. (With Bur. Plant Indus.)

Harvesting pyrethrum. By A. F. Sievers, M. S. Lowman, and W. M. Hurst. U. S. Dept. Agr. Cir. 581. (With Bur. Plant Indus.)

Experiments in the use of vapor-spray equipment. By O. K. Hedden and R. M. Merrill. U. S. Dept. Agr. Cir. 598.

Machinery for growing corn. By C. K. Shedd, J. B. Davidson, and E. V. Collins. U. S. Dept. Agr. Cir. 592. (With Iowa Agr. Expt. Sta.)

Field tests of mechanical blocking and thinning of sugar beets. By E. M. Mervine. Amer. Soc. Sugar Beet Technologists Proc. 2: 256–257 and 259. 1940.

Fertilizer placement experiments with sugar beets in Ohio. By J. G. Lill, R. M. Salter, G. A. Cumings, and L. A. Hurst. Sugar Beet Jour. 6 (9): 169–175. 1941. (With Bur. Plant Indus. and Ohio Agr. Expt. Sta.)

Physical reactions of soils on plow disks. By E. D. Gordon. Agr. Engin. 22: 205–208. 1941.

Results of row spacing experiments with corn. By E. V. Collins and C. K. Shedd. Agr. Engin. 22: 177–178. 1941.

Machines designed for harvesting and storing grass silage. By H. E. Besley and W. R. Humphries. Agr. Engin. 22: 125–126. 1941. (With N. J. Agr. Expt. Sta.)

Effect of shape on the draft of 14-inch moldboard plows. By I. F. Reed. Agr. Engin. 22: 101–104. 1941.

Equipment for cultivating corn. By C. K. Shedd and E. V. Collins. Agr. Engin. 22: 5–6. 1941. (With Iowa Agr. Expt. Sta.)

Mechanical corn picking. By C. K. Shedd and E. V. Collins. Farm Sci. Rpt. 1 (4): 3–5. 1940. (With Iowa Agr. Expt. Sta.)

Some results of a corn husking mechanism study. By E. V. Collins, J. M. Trummel, and C. K. Shedd. Agr. Engin. 21: 425–428. 1940. (With Iowa Agr. Expt. Sta.)

A variable width plow. By E. V. Collins and C. K. Shedd. Agr. Engin. 21: 1. 1940. (With Iowa Agr. Expt. Sta.)

Experiments with pea fertilizer placement in Maryland. By C. H. Mahoney, H. A. Hunter, Albert White, G. A. Cumings, L. G. Schoenleber, and D. B. Eldredge. Canner 92 (20): 32–34 and 36. 1941. (With Univ. Md.)

Reducing power waste in operating cotton gins. By Victor L. Stedronsky, Thomas L. Baggette, and Arvid J. Johnson. U. S. Dept. Agr. Cir. 601. (With Agr. Market. Serv.)

The vertical drier for seed cotton. By Charles A. Bennett and Francis L. Gerdes. U. S. Dept. Agr. Misc. Pub. 239. (Revised March 1941.) (With Agr. Market. Serv.)

Better ginning by repairing cotton gins. By Charles A. Bennett. Cotton and Cotton Oil Press 42 (9): 5 and 20 ACE–98 (mimeographed) 1941.

Better ginning service with new gin installations. By Francis L. Gerdes and Charles A. Bennett. Cotton and Cotton Oil Press 42 (6): 20–21 and 44. (Mimeographed.) 1941. ACE–84.

Unloading-fan improvements for increased efficiency in cotton ginning. By Charles A. Bennett and Francis L. Gerdes. Cotton Ginners' Jour. 12 (6): 5 and 16–17; ACE–94. (Mimeographed.) 1941. (Witn Agr. Market. Serv.)

Surveying power consumption at gins. By V. L. Stedronsky, T. L. Baggette, and A. J. Johnson. Cotton Ginners' Jour. 12 (4): 5–6 and 14. 1941. (With Agr. Market. Serv.)

The operation and care of gin saw sharpening machinery. By Charles A. Bennett and F. L. Gerdes. Cotton Ginners' Jour. 12 (2): 5–6. 1940. (With Agr. Market. Serv.)

Preliminary report on 1939–40 developments at the U. S. Cotton Ginning Laboratory. By Charles A. Bennett and Francis L. Gerdes. Cotton Ginners' Jour. 11 (10): 7, 13 and 16, 1940. (With Agr. Market. Serv.)

Speeding up gin-saws to improve ginning quality and efficiency. By Francis L. Gerdes and Charles A. Bennett. Cotton Ginners'. Jour. 12 (1): 7 and 11. 1940. (With Agr. Market. Serv.)

Ginning and packaging research. By C. A. Bennett and F. L. Gerdes. ACE–61. (Mimeographed.) 1940. (With Agr. Market. Serv.)

The compression of cotton and related problems. By John W. Wright and Charles A. Bennett. ACE–67. (Mimeographed.) 1940. (With Agr. Market. Serv.)

Roller-gin construction, maintenance, and operation. By James S. Townsend, Thomas C. Walton, and William J. Martin. ACE–68. (Mimeographed.) 1940. (With Bur. Plant Indus. and Agr. Market. Serv.)

Sea-island cotton quality and ginning. By W. J. Martin, J. S. Townsend, and Thomas C. Walton. ACE–69. (Mimeographed.) 1940. (With Agr. Market. Serv. and Bur. Plant Indus.)

Developments in roller covering for roller cotton gins. By James S. Townsend and staff members of U. S. Cotton Ginning Laboratory. ACE–85. (Mimeographed.) 1941. (With Bur. Plant Indus.)

The ginners' part in cotton-quality improvement. By Francis L. Gerdes and Charles A. Bennett. ACE–90. (Mimeographed.) 1941. (With Agr. Market. Serv.)

Modern cotton ginning requirements in Arkansas and Missouri. By C. A. Bennett. ACE–95. (Mimeographed.) 1941.

Current cotton ginning machinery and practices. By C. A. Bennett and F. L. Gerdes. ACE–96. (Mimeographed.) 1941. (With Agr. Market. Serv.)

Cotton ginning in Arkansas and Missouri and efforts to promote its improvement. By Francis L. Gerdes and Charles A. Bennett. ACE–97. (Mimeographed.) 1941. (With Agr. Market. Serv.)

Better ginning with higher gin saw speeds. By Charles A. Bennett and F. L. Gerdes. ACE–100. (Mimeographed.) 1941. (With Agr. Market. Serv.)

Some benefits from modernizing cotton gins. By Charles A. Bennett and Francis L. Gerdes. ACE–102. (Mimeographed.) 1941. (With Agr. Market. Serv.)

Preventing gin damage to cotton in Georgia. By Francis L. Gerdes and Charles H. Bennett. ACE–107. (Mimeographed.) 1941. (With Agr. Market. Serv.)

Gin modernization in Tennessee. By Charles A. Bennett and Francis L. Gerdes. ACE–108. (Mimeographed.) 1941. (With Agr. Market. Serv.)

Better ginning to enhance cotton quality and utility. By Charles A. Bennett. ACE–109. (Mimeographed.) 1941.

Electric light for the farmstead. Prepared by the Bureaus of Agricultural Chemistry and Engineering and Home Economics. U. S. Dept. Agr. Farmers' Bul. 1838.

Electric motors for the farm. By Harry L. Garver, O. A. Brown, J. T. Bowen, and R. B. Gray. U. S. Dept. Agr. Farmers' Bul. 1858.

Studies of artificial lighting of dairy stables. By M. A. R. Kelley and A. V. Krewatch. Agr. Engin. 21 : 445–449 ; ACE–56. (Mimeographed.) 1940. (With Univ. Md.)

Rural electrification investigations. By C. E. Seitz. Va. Polytech. Inst. Bul. 34 (3) : 23–37. 1940.

Tank heater studies. By F. D. Yung. Agr. Engin. Prog. Rpt. 7 : 1–10. 1940.

Cooling eggs on the farm and at grading stations. By J. W. Weaver, Jr., Reece L. Bryant, and Cecil Rogers. ACE–104. (Mimeographed.) 1941. (With Va. Polytech. Inst. and Va. State Market. Serv.)

Poultry housing—a selected list of references. Compiled by M. A. R. Kelley ; edited by Dorothy W. Graf. Bur. Agr. Chem. and Engin. (Mimeographed.) 1941.

MISCELLANEOUS

Report of the Chief of the Bureau of Agricultural Chemistry and Engineering, 1940 (for the fiscal year ended June 30, 1940).

Thermal decomposition of undercured alfalfa hay in its relation to spontaneous ignition. By E. J. Hoffman. Jour. Agr. Res. 61 : 241–258. 1940.

The place of the engineer in research on the utilization of farm products. By Henry G. Knight. W. Va. Engin. 2 (9) : 16–19. 1940.

Industrial utilization of southern farm crops. By Henry G. Knight. Mfrs. Rec., South's Resources, pp. 44–46. Sept. 1940.

Many accidents on the farm take a heavy toll every year. By David J. Price and Harry E. Roethe. Natl. Grange Monthly 37 (7) : 3. 1940.

Farm research narratives—industrial utilization of farm products. By Henry G. Knight. Agr. Ed. 13 (12) : 224–266. 1941.

Research on present uses of cotton and cottonseed. By Henry G. Knight. ACE–106. (Mimeographed.) 1941.

Accomplishments of the Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture. By Henry G. Knight. Chem. 18 (5) : 185–194 ; ACE–91. (Mimeographed.) 1941.

Agricultural and technological observations with different sugar producing crops. By C. A. Browne. Arch. v. Suikerindus. Nederland, Indië. 9 : 1–9. 1940.

Lactic acid as a component of synthetic resins. By J. T. Stearn, B. Makower, and P. H. Groggins. Indus. and Engin. Chem. 32 : 1335–1342. 1940.

Action of lead tetraacetate upon hydroxylated fat acids and related compounds. I. Hydroxylated oleic acid, ethyl oleate, and oleyl alcohol. By John T. Scanlan and Daniel Swern. Amer. Chem. Soc. Jour. 62 : 2305–2309. 1940.

Action of lead tetraacetate upon hydroxylated fat acids and related compounds. II. Hydroxylated ricinoleic acid and castor oil. By John T. Scanlan and Daniel Swern. Amer. Chem. Soc. Jour. 62 : 3309–2311. 1940.

Sulfonated arylstearic acids, Wetting properties of the sodium salts. By A. J. Stirton, R. F. Peterson, and P. H. Groggins. Indus. and Engin. Chem. 32 : 1136–1137. 1940.

Farm products and by products for industrial use. By W. W. Skinner, H. P. Holman, V. A. Pease, T. D. Jarrell, C. E. Senseman, and A. B. Genung. ACE–55 (Mimeographed.)

List of translations available in the U. S. Department of Agriculture. Bur. Agr. Chem. and Engin. (Mimeographed.) 1941.

UNITED STATES PATENTS

Aqueous Dispersion of Hardened Protein. By George H. Brother and Allan K. Smith. U. S. Patent No. 2,210,481 ; August 6, 1940.

Process for Making Synthetic Manure. By Martin Leatherman. U. S. Patent No. 2,218,695 ; October 22, 1940.

Cotton Fan. By Gerald N. Franks. U. S. Patent No. 2,225,397 ; December 17, 1940.

Method of Drying Grain. By William V. Hukill. U. S. Patent No. 2,235,748 ; March 18, 1941.

Thermoplastic Protein Material. By George H. Brother and Leonard L. McKinney. U. S. Patent No. 2,238,307 ; April 15, 1941.

Mildewproofing and Mothproofing Treatment. By Martin Leatherman. U. S. Patent No. 2,238,850 ; April 15, 1941.

Stable Rosin Acid, Rosin Ester, and Rosin Product Containing Them and a Method for Their Production. By E. E. Fleck and S. Palkin. U. S. Patent No. 2,239,555 ; April 22, 1941.

U. S. GOVERNMENT PRINTING OFFICE: 1942