University and Station Role in Training

The land-grant college system, concept, and idea now represent more than 100 years of experience in higher education and research. It is based upon the idea that progress or advancement is most likely to come by increased educational opportunity and by advancement of science through investigation and experiment.

The Hatch Experiment Station Act provided for participation with the U. S. federal Department of Agriculture in a nationwide agricultural research program. This act, as amended, has assisted in the establishment and maintenance of an agricultural experiment station in each state. It is recognized, I believe, as providing the first system of institutional grants. Through the years, the partnership between the states and the USDA has stimulated cooperative research. Technological developments in agriculture stemming from research in the USDA and state stations and education in the land-grant institutions have done much to enable us to attain the high standards of living we enjoy today.

The role of the land-grant institutions in the education of undergraduate and graduate students has been of great significance. Such education has helped provide trained scientists for the chemical industries, government, state, and private laboratories. Graduate students also have made significant contributions as research assistants.

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WORLD-WIDE RESEARCH

Expanding the Use of Farm Products

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Research in chemistry and allied sciences has contributed much to the development of new or improved food and industrial products from farm crops. Such research is being conducted more in the United States than elsewhere, undoubtedly because of our plentiful supply of agricultural materials, but other countries are awakening to its need and value. In the United States, the major stimulus on problems of national or regional importance is provided by USDA, primarily through the four Regional Research Laboratories, which began operations in 1941 when surplus crops were becoming an increasingly important problem in the agricultural economy. The in-house research at the Regional Laboratories is supplemented by a sizable domestic contract program; additionally, important results are being obtained under a program of grants to foreign institutions. The presentation reviews some of the accomplishments of USDA's utilization research program and some of the problems currently being attacked.

IN THIS symposium, papers presented by scientists representing laboratories here and abroad, on widely varied subjects, illustrate the diversity of present-day agricultural chemistry, and emphasize the fact that many of the world's outstanding scientists are now engaged in such research. Agricultural chemistry is no longer a pursuit where simple analyses for nitrogen, phosphorus, potash, and crude fiber constitute a significant part of the agricultural chemist's daily work. It is a discipline where the best of organic chemists, biochemists, and physical chemists utilize and develop the most modern of techniques to increase our information concerning agricultural products, their production, and their use.

Since much of the work described is being done under support by the Department of Agriculture or with its collaboration, it is fitting to provide more detail concerning that part of the Department of Agriculture—the Utilization Research and Development Divisions—which is primarily concerned with the kind of agricultural chemistry discussed in this symposium.

The current USDA utilization research program began with the establishment of four Regional Laboratories, beginning in 1941, in Peoria, Ill., New Orleans, La., Philadelphia, Pa., and Albany, Calif. A fifth Regional Laboratory will be constructed at Athens, Ga., to provide for concerted research on the principal agricultural commodities of the Southeast. In addition, there are 10 associated field stations, and a sizable domestic program of contracts and grants in which utilization research is conducted at other institutions.

Currently, about 1000 scientists and an equal number of supporting per-

sonnel carry out the work of the laboratories. When the Southeastern Regional Laboratory is completed and programs for enlarging the existing Regional Laboratories are finished, our facilities will accommodate a 50% expansion of personnel.

The research program includes the major agricultural commodities produced in this country: the fiber crops, cotton and wool; oilseeds, including soybeans, flaxseed, cottonseed, safflower, tung, and castor; animal products, which include dairy products, meat, animal fats, poultry and eggs, and associated products; fruits and vegetables; cereal grains and forages; and sugar and special plants. Included in the latter category are cane and beet sugar, honey, and maple products, as well as naval stores, tobacco, and new crops.

The scope of this program, thus, is broad, in terms of both commodities—for which new and improved products, processes, and uses are sought—and the varied and diverse chemical, physical, and biological problems which must be solved to achieve these objectives. This discussion provides some examples of the kind of research now under way to attack these problems.

Cotton and Wool

The problem that currently faces cotton and wool, and one that promises to increase in the future, is competition from synthetic fibers. Adoption of the synthetics has been based on their properties, such as shrink and wrinkle resistance, quickness to dry, and ability to hold pleats and creases—an aggregate of properties commonly described as ease-of-care performance. This is not to say that the synthetics possess across-the-board superiority to the natural fibers, but their superiority in certain aspects has enabled them to capture a significant part of the textile fiber market.

Developments by the Southern Division in wash-wear cotton fabrics and, more recently, the new stretch fabrics, have been of major importance in meeting competition from the synthetics. Development by the Western Division of methods for the interfacial polymerization of resins on the wool fiber—the Wurlan process for easy-care wool fabrics—has promise of similar importance in retaining and expanding the markets for wool.

Continued improvements are necessary—for example, better wash-wear treatments, improved resistance to abrasion and tearing, better resistance to soiling, resistance to yellowing in wool, and methods for achieving luster without sacrificing other properties. Achievement of these improvements will be accelerated by an understanding of the basic structure of the natural fibers, the relationship of structure to fiber properties, and the ability to effect desired alteration of fiber structure by chemical or physical treatments.

As an example of the basic research on fibers, H. F. Launer at the Western Division has been working on the effect of light upon wool. This work is important to the yellowing problem, but its ultimate significance may be far greater. By investigating the electron paramagnetic resonance spectrum of wool, Launer has found that wool contains a naturally occurring, stable free radical in low concentration. In contrast to this natural free radical, the radicals produced by ultraviolet or x-rays are unstable to heat, water, or oxygen.

Ultraviolet light can turn wool green, yellow, or white, the color depending on the wavelength of the incident radiation and conditions of irradiation. Comparisons of electron paramagnetic resonance spectra of irradiated wool and irradiated individual amino acids show that the spectrum obtained with green wool could be accounted for by tyrosine and cystine radicals. On exposure to water vapor, the green color changed to yellow in a short while, and the free radical spectrum eventually changed to the stable natural radical.

Amino acid analyses of wools which have been extensively irradiated with ultraviolet light showed that glycine and alanine increased slightly whereas all other amino acids decreased, cystine disappearing completely. Several new amino acids appeared as the result of either the methylation or demethylation of a naturally occurring amino acid. The end result of irradiation of wool is to turn it yellow.

Such information on the mechanism of yellowing of wool may provide a basis for its prevention, and may lead as well to many other developments.

Oilseeds

Markets for vegetable oils are found in both food and industrial applications; soybean, cottonseed, and safflower oil find use in both markets whereas linseed, castor, and tung oil go entirely into industrial or nonfood applications.

Prospects for increasing the per capita consumption of edible fats and oils will likely increase only as our population increases. Demand for oilseed meals for our expanding livestock and poultry industry continues to increase more rapidly than our population growth, and this has resulted in production of vegetable oils from our domestic crushings that is surplus to our need. A most promising outlet for our excess oils, and for the soybeans surplus to our domestic need, lies in the dollar export markets of Europe and Japan. The quality products needed to compete call for research which will, for example, provide a basis for economical processes for production of flavor-stable cooking oils from soybeans, and cottonseed oil of improved color.

The same qualities of these oils are needed for our domestic market. Per capita consumption of cooking and salad oils has doubled in the past 15 years and continues to increase. The increasing attention to the relation between diet and health demands products which nutritional research shows most desirable.

An example of current research on vegetable oils is the work at the Northern Division on the flavor stability of soybean oil. Some years ago it was established that the 6 to 8% of linolenic acid in soybean oil was the precursor of the reverted flavor which developed on oxidation. Presumably, oxidation products at the 15, 16 double bond give rise to the undesirable flavors and odors; and selective hydrogenation of soybean oil to remove linolenic acid by saturating its 15, 16 double bond, thereby converting it to the natural linoleic acid, would be the ideal process for making a flavor-stable oil.

To explore the feasibility of such a selective process, basic studies are under way on the kinetics and mechanism of hydrogenation of unsaturated fatty acids, employing both heterogeneous and homogeneous catalysts. Certain similarities appear to exist in the mechanisms of reactions with the two types of catalysts. Definite complexes of catalyst with unsaturated fatty acids—e.g., iron carbonyl-linolenic acid complexes—have been isolated and their structures established by nuclear magnetic resonance, thus providing definite evidence on the nature of the interaction of catalyst and substrate. Work with homogeneous catalysts has also demonstrated the transfer of hydrogen from combination with the catalyst to the fatty acid.

Oilseed Protein Products

In addition to the oil, the protein of oilseed crops is a valuable constituent. Demand for oilseed meals for livestock and poultry feeds has been increasing steadily. Not all oilseed meals can serve as animal feeds—for example, castor bean meal as conventionally produced contains allergens which relegate it to use as a fertilizer. A process involving alkaline treatments was developed which inactivated these allergens; it is now being tested by commercial processors.

Cottonseed meal contains gossypol and other antinutritional factors that are not completely removed or neutralized in conventional processing. These constituents limit the nutritional value of the meal, especially in the case of monogastric animals. A new oil extraction process based on a mixed solvent system,

now under development at the Southern Division, gives promise of nearly complete removal of the gossypol and production of a more nutritious meal.

A growing interest is developing in oilseed protein products in the food field. Currently the Northern and Southern Divisions are cooperating with UNICEF and AID in the development of inexpensive protein food products for children, and supplements to native diets, from soybeans and cottonseed.

Animal Products

Animal products, including meats, milk, poultry, eggs, and associated products, are an important group of commodities for utilization research, since they represent around 55% of the farmer's cash receipts. Moreover, the major portion of the feed grains and forages grown in the U. S. are used in their production. Consequently, any research which succeeds in stimulating an increase in the consumption of this commodity group provides a powerful stimulus to U. S. agriculture. Obvious, therefore, is the importance of research resulting in lower meat-handling and processing costs. A second approach to increased consumption of meat is through improvement in quality of the lower-grade cuts. Still another area for research is the development of new and improved processed meat products utilizing these lower-grade cuts.

In the poultry and egg industries, many of the problems mentioned for red meat and the projects under way apply equally well to poultry meat.

The 1.8 billion dollar egg industry is periodically faced with a burdensome surplus and declining per capita consumption that drives prices below the breakeven point for many producers. Increased utilization of eggs must come in the form of new egg products that compete by virtue of superior quality and convenience. The potential of egg powder in products such as convenience foods can be realized, however, only with improvement of flavor stability, dispersibility, and freedom from pathogenic *Salmonella* bacteria. Thus, more emphasis has been placed on the characterization of the egg proteins, lipids, and enzymes in relation to these properties.

Satisfactory pasteurization of liquid egg white is difficult to achieve since conalbumin is easily denatured by heat, resulting in loss of functional properties. Basic studies of the properties of conalbumin showed it to be stabilized toward denaturation when complexed with iron or aluminum. Based on this observation, it was found possible to protect egg white, at pasteurization conditions adequate to assure complete safety from *Salmonella*, simply by adding sufficient aluminum salt to complex all the conalbumin. (Because iron colors the egg white pink, aluminum is the metal of choice.) This latest accomplishment of egg research is now being adopted by egg processors.

An important area for research on milk which should encourage increased consumption is work on the improvement in quality of manufactured dairy products, cost reductions based on improved processing technology, the development of new products, or any combination of these. Need exists for developing improved liquid milk concentrates of beverage quality. Substantial progress has recently been made with respect to viscosity characteristics of these products, but formidable problems remain in achieving flavor stability.

The profitable utilization of animal fats and hides is an important element in the economics of the livestock industry, since it is reflected in the price of meat to the consumer. Petroleum-based detergents have made deep inroads in the soap market for animal fats, and synthetic plastics have replaced about 7,000,000 cattle hides formerly used for shoe soles. Opportunities exist for new chemical derivatives of fatty acids in the lubricant, plasticizer, and plastics market. The current need for biodegradable detergents which can be readily derived from animal fats offers possibilities for recapture of part of the lost soap market. For hides, processing costs need to be lowered, and new types of tannages need to be developed which will yield leather with more versatile characteristics. Current consideration is being given to uses for hide collagen in the food field.

Cereal Grains

The abundant supply of corn, wheat, and other cereal grains beyond those amounts required to satisfy the need, is the basis for a strong research program on the development of new products for use by industry, as well as for improved foods and feeds.

Starch accounts for about two thirds the weight of all grains. Finding new, large-volume outlets for starch would, therefore, result in substantially increased consumption of cereal grains. Some 2 billion pounds of starch now find industrial applications that offer opportunities for increases at a rate greater than population growth. The paper and paper products industry offers a large and expanding market for new starch products as wet-end additives, surface sizes, and coating adhesives. Recent products are the dialdehyde starches developed at the Northern Division and now used commercially to impart wet strength to paper. The starch xanthides now under development offer promise as low-cost paper additives which will give substantial improvements in both dry and wet strength, and in stiffness at high relative humidity, a property particularly desired in corrugated boxboard.

Fermentative production of new products from starch through the action of microorganisms is a field for research deserving attention. Microorganisms can produce high-molecular-weight polysaccharides from glucose in high yield. Wide variations in structure can be achieved, with corresponding differences in properties of the polysaccharides. These polysaccharides are now in small-scale commercial production.

Fermentation technology offers a route to the utilization of cereal grains through the production of biological insecticides and antibiotics against plant disease. An example is the problem of growing and producing spores of the bacterial pathogens which cause milky disease in Japanese beetles. Distribution of these spores in areas infested with the Japanese beetle would be a control measure, specific to the Japanese beetle, that does not have the residue problems of many of the chemical pesticides. Inducing the pathogen to sporulate in deep tank fermentations, however, is a difficult problem and has taken microbiologists at the Northern Division deep into the factors affecting sporulation.

Wheat

Utilization of superabundant supplies of wheat as a food grain presents many interesting problems for research. In the domestic market, the problem is to stem the continual shrinking of markets for wheat products. To solve this problem, wheat products must have the same factors—of diet control and rich flavor, variety, and convenience—that make their competition attractive. Studies by the Western Division on freezing preservation of bread have made basic contributions to this rapidly growing method of marketing bread, cakes, and other baked goods.

The variety of flour products that can be achieved by air classification is being explored. In this way, special properties for particular food uses can be enhanced.

Variety and convenience of wheat food products can be achieved through nonbaked wheat products. Processes for making and canning bulgur, a partially debranned parboiled wheat which Middle Eastern people have long eaten, have been developed. New ready-to-eat foods derived from bulgur, new chemical processes for "peeling" wheat, fermented wheat foods, and textured foods based on wheat gluten as a binder are being studied.

Utilization research can contribute to the competitive position of U. S. wheats by developing strong bread doughs without additives, developing dough-strengthening methods acceptable to Common Market countries, and

developing high-strength blending flour fractions from U. S. air classified flour.

Industrial uses of wheat constitute a long-range market not competitive with food uses. Increasing efficiency of production and changing economic patterns make this a challenging possibility. We are studying the composition of gluten proteins, how their unique properties derive from their structure, and how they can be chemically modified.

Another approach is to use flour as a chemical raw material, for it is available in large quantities at relatively low cost. Flour consists essentially of starch and gluten protein; both constituents have uses as binders, adhesives, and thickeners.

Fruits and Vegetables

More than half of the fruits and vegetables now marketed in the United States are in processed form. Indications for the future point to an increasing proportion of processed products. Despite the gains in quality realized by freezing, many unsolved problems remain. One of these occurs in peaches, which undergo enzymatic browning in the frozen condition. In studies at the Western Division, an enzyme has been separated from several plant tissues which, when applied to peaches, prevents surface enzymatic browning. This enzyme has been identified as 3-*O*-methyl transferase; it acts by causing the methylation of catechol derivatives, which in their natural form undergo browning.

Interestingly enough, one of the plant sources of this enzyme is apple cambium, but it is well known that a cut apple exhibits rapid enzymatic browning. This apparent paradox was explained by the discovery that the enzyme had optimum activity at high pH, and adjustment of acidity of the cut apple permanently prevented browning.

The introduction of gas-liquid chromatography has rapidly advanced the chemistry of volatile flavor components of fruits and vegetables during the past few years. Chemical studies of flavor components must, of course, be correlated with subjective evaluations by trained taste panels. Such panels can determine odor thresholds of aqueous solutions of individual components of fruit or vegetable volatiles which appear to be related to product aroma. Chemists at the Western Division have demonstrated that an additive relationship exists between total concentration of the mixture and threshold olfactory response. Thus the aroma threshold of a 10-component mixture was identified by a taste panel when each of the compounds was present at one tenth of its individual threshold concentration. This finding would appear to be an important one and an early step toward interpretation, in terms of flavor, of the complicated chromatograms obtained in chemical studies.

Tobacco Research

Prior to January 1964, emphasis was on the relationship between tobacco leaf and smoke composition and smoking quality. Since publication of the Surgeon General's report on "Smoking and Health" last January, the tobacco program has been largely reoriented to health-related problems. Congress has provided increased funds in current appropriations for investigations in this field. More should be known about the composition of tobacco leaf and smoke and the properties of individual components. Arrangements have been made with the U. S. Department of Health, Education, and Welfare to study the medical implications of such information as it becomes available.

Conclusions

The problems that the Utilization Research Divisions seek to solve are the practical ones facing agriculture, but solutions will be reached most rapidly through a blend of basic and applied research, with increasing emphasis on the basic as the program expands. This research and that conducted at universities and other institutions will provide a firm basis for advances in the better utilization of agricultural products, both here and abroad.

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The following additional papers were presented orally as part of the symposium:

"Causes and Control of Darkening of Plant Tissues with Especial Reference to the Potato," E. C. Bate-Smith, J. C. Hughes, J. B. Pridham, L. W. Mapson, D. A. Robb, and T. Swain, Low Temperature Research Station, Cambridge, England;

"Antioxidant Components of Wood Smoke Used in the Curing of Meat," D. J. Tilgner and Z. Sikorski, Technical University, Politechnika Gdanska, Gdansk, Poland;

"The Amination of Starch," M. L. Wolfrom, Ohio State University, Columbus, Ohio;

"Effect of Synthetic Chelates on the Autoxidation of Unsaturated Fatty Acids," Giovanni Jacini and Enzo Fedeli, Stazione Sperimentale Olii e Grassi, Milano, Italy;

"Studies in the Hydroboration of Terpenes," H. C. Brown, Purdue University, Lafayette, Ind.

END OF SYMPOSIUM

ORANGE PEEL CONSTITUENTS

Flavones of the Neutral Fraction of the Benzene Extractables of an Orange Peel Juice

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The proximate analyses of orange peel juice samples collected over a period of 2 seasons are given in another paper (*4*). Among the properties determined on the whole juices were the taste thresholds when added to commercial orange juice and the amounts of benzene-extractable material present. The benzene extracts were then separated into acidic, neutral, and lactonic fractions. Since the neutral fractions were usually the largest and known to be bitter, their taste thresholds were also determined. These considerations seemed to warrant an investigation of the nature of the neutral fraction in greater detail. The approach chosen to the problem of separation was by column chromatography