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MAY 1979

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Research at the Eastern Regional

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Editor's Note: Each USDA Regional Research Center was contacted and asked for updates on research done in the past year and the immediate future for this research. Following are responses from three of the labs.

The Eastern Regional Research Center (ERRC) has a 40-year history in agricultural research. In the post-Depression era during a time of burdensome farm surpluses, the U.S. Congress reacted by establishing the four regional laboratories. The ERRC, just outside Philadelphia, was commissioned to undertake investigations in animal products—dairy, meats, animal fats, hides, and leather—and in fruit and vegetable products as well as honey and maple syrup. The objective of its original studies was to find new uses for agricultural commodities; frequently this meant industrial or nonfood applications. A typical development from the early research led to the production, from animal fats, of epoxidized fats and oils as internal stabilizer-plasticizers for vinyl resins. Another was the use of tallow in livestock feeds (now the largest single application of inedible tallow). A new glutaraldehyde tanning method for skins and hides was developed, making leather that is perspiration-resistant and extremely durable; the tanning agent is used extensively on shearlings for hospital bed pads, paint rollers, and leather for military gear. Numerous studies were successful in treating wastes from agricultural processes—work that continues today in a vital role for environmental protection.

The ERRC developed new technologies for the quality maintenance of mechanically harvested fruits, designed a practical system for collecting maple sap and making it into syrup, developed fruit juice concentrates and essences that enabled new uses, and engineered the largest volume dry convenience food—dehydrated potato flakes. The ERRC also developed low-fat cheese products and whole-milk powder by foam spray or vacuum foam drying and improved preservation of apple cider. Further efforts were successful in developing analytical methodology used throughout the world today. The latter type of research continues as regulations become more complicated and processors need to keep pace with change. This background and synopsis of a few achievements set the stage on which emerging new roles in research are played. New societal factors help to govern the perpetual redirection efforts that have kept the agricultural research centers timely and productive.

Especially in the last decade, evolutionary change in the directions of research has taken place at the regional centers. Postharvest science and technology research, dedicated to the fate of agricultural materials after they leave the farm, has continued to improve processing, preservation, and distribution efficiency. Basic compositional research and knowledge of constituents have led to better understanding of the biochemistry and microbiology of commodities and have been the foundation from which new and improved products or handling and uses have been derived, for the benefit of producers, consumers, and industry.

Investigations at ERRC and other research centers have broadened considerably in response to national needs and the socioeconomic goals of the federal government. These include energy and renewable resources; environmental considerations such as pollution control, waste management, and reduced pesticide residues; enhanced productivity through new technology and increased efficiency for small farmers, processors, and distributors by reducing postharvest processing costs; reduction of losses in the agricultural food chain; wholesomeness of foods, and health and safety of consumers and workers; product quality including nutrition; and improvement in balance of payments through expansion of exports and reduced imports. Two complementary categories to be considered are support of regulatory and action agencies; and finally, basic research, systematic inquiries designed to develop fundamental facts and theories. Evaluation of the significance, impact, and priority of research according to these new criteria is a current major responsibility of federal research management. Such judgment factors and accountability will undoubtedly continue into the 1980s.

Illustrated in Fig. 1 are the kinds of changes that have taken place in the 1970s in ERRC research. Apparent are increases in basic research and research in food safety and plant and animal physiology. In the latter are research programs such as biochemistry of lactation, study of alkaloid synthesis in food and narcotic plants, stress metabolites in foods, and host plant-parasite interactions. Typical areas of food safety emphasis have been nitrites and nitrosamines, harmful microorganisms and natural toxicants in foods, and chemical and drug residues. Also shown in Fig. 1 is the redirection of some effort away from the more traditional programs of process and product development. Included in the term productivity are cooperative efforts with production agricultural workers in areas such as plant hormone structures, soil permeability, and basic chemical studies relating leaf protein composition to agronomic characteristics such as disease resistance.

Figures 2–4 show trends in selected research areas at ERRC in the last decade. Basic research (Fig. 2) declined in quantity early in the 1970s when the watchword was relevance and all research needed a rather specific and well-defined raison d'être. When it was realized that emphasis on innovation and creativity were of prime national importance, the amount of basic research was again increased. Food safety and health research (Fig. 3) has continually increased in response to consumer concerns, and this trend may well continue for some years. Research at ERRC on environmental quality reached a maximum in the early and middle 1970s and declined as industry adjusted to new guidelines and began working out some of its own solutions. The federal laboratories will probably have a continuing responsibility in this research area but not at the peak levels of earlier years. The classification of research into pigeonholes is subjective. The information in Figs. 1–4 illustrates trends, but the figures should not be taken too literally as precise values.

Among the mix of programs at the ERRC are some that are rather directly responsive to specific problems brought to our attention, frequently by other agencies.

The scope of research at the ERRC is further exemplified by a few selections from active projects. This research is performed by interdisciplinary teams under an organizational framework of seven laboratories; five have primary responsibility for particular commodities, and two, of disciplinary orientation (Physical Chemistry and Engineering and Development), operate across the board with the other five.

Dairy Research

Dairy research at ERRC involves fundamental investigations regarding chemical, physical, biological, and microbiological properties of milk, milk components, and dairy products. Studies are designed to increase our knowledge of the interactions between proteins, lipids, and carbohydrates, in situ, and the contributions of these interactions to nutrition and food technology. In addition, fundamental studies are conducted on milk biosynthesis and on microbial physiology and biochemistry. With the demise of many dairy science departments at major universities, dairy research at ERRC represents a unique interdisciplinary resource for work on dairy-related problems in a single well-equipped facility.

Eastern Regional Research Center - Program Redirections
FY 1970 - FY 1979

Goals	FY 70, %	SY Decrease, %	SY Increase, %	FY 79, %
Plant & Animal Physiology	0			9
Energy	0			2
Environment	10			11
Productivity - Food	50			36
Productivity - Non-Food and Fiber	31			9
Health and Safety	7			33
Balance of Payments	2			0
Totals	100			100
Basic Research	55			65

Fig. 1

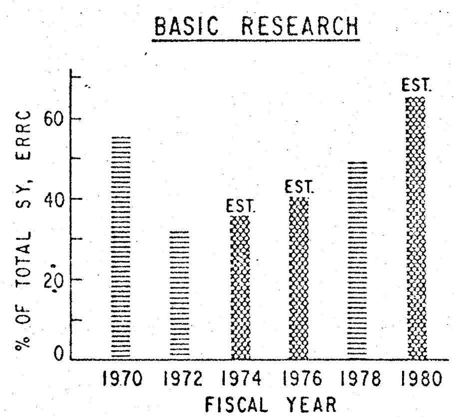

Fig. 2

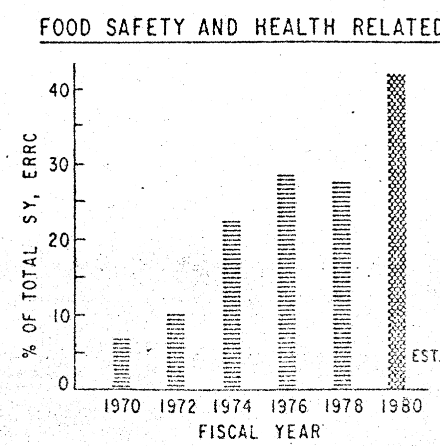

Fig. 3

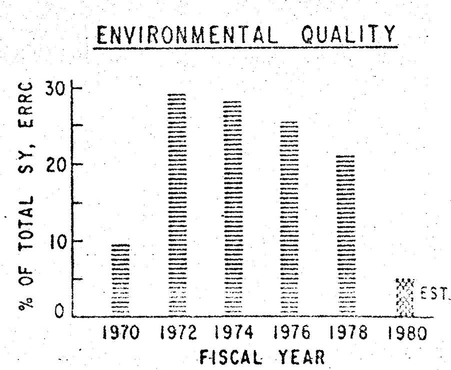

Fig. 4

A major research effort has been directed toward increasing whey utilization beyond the current 60% level. The use of whole whey and of whey components has been studied. The high quality protein in whey makes it a natural food component to increase the nutritional quality of foods containing plant proteins. Two whey-based beverage products, whey-soy and whey-peanut, were developed recently, both acceptable for use in overseas feeding programs; the latter may also have potential in domestic programs. Whey-protein concentrates appear to have significant marketability but the by-product lactose does not. Efforts to increase lactose utilization through chemical modification have led to the development of lactose esters for possible use as surfactants and lactobionic acid with sequesterant properties. In model systems lactulose obtained from isomerization of lactose is more effective than glycerol or sucrose in lowering the water activity in intermediate moisture foods. Fundamental chemical studies on lactose have led to the development of a unique method for assigning structures and conformations to carbohydrates and polysaccharides. The method, based on measuring the differential isotope shift of nuclear magnetic resonance, is already being applied widely in the carbohydrate field.

Improvements in dairy breeding and management practices have brought about increases in milk yields. However, further optimization of milk production may not be possible without a fundamental understanding of the biochemical processes involved in the synthesis and secretion of milk. Such studies are under way at ERRC. For example, milk is a rich source of calcium, phosphorus, and protein (casein). In lactating cells, the Golgi vacuoles serve as a processing room for skim milk. The enzyme, casein kinase, which was discovered at ERRC, is localized in the Golgi complex and completes the assembly of casein by chemically adding phosphate. In turn, the casein phosphorus carries the calcium into milk. Future studies on the enzymology of lactation, combined with physiological studies, will lead to an overview of lactation and provide a sound biological basis for selection of more efficient milk-producing animals.

Meat Research

Meat research is directed to basic chemical, biochemical, and microbiological studies of meats and meat products to provide information for safer, more nutritious, and higher quality products. Current emphasis is on safety.

One of the major problems facing the meat industry is the presumed hazard in the use of nitrite in curing meat products. Not only does nitrite react with secondary amines during frying of bacon to form potentially carcinogenic nitrosamines, but a recent MIT study seems to implicate nitrite itself as a carcinogen in rats. The ERRC has been in the forefront of research to develop analytical procedures for detecting trace quantities of nitrosamines, to investigate factors involved in nitrosamine formation and how to prevent it, and more recently, to study nitrosamine formation in the human body. Ascorbate, or erythorbate, was first shown at the ERRC to reduce nitrosamine formation in bacon, and results of recent studies demonstrating the efficacy of α-tocopherol as an inhibitor have been evaluated in commercial tests by the industry. More than 300 chemicals have been studied as substitutes for nitrite in preventing the growth of *Clostridium botulinum* and avoiding food poisoning. Other food poisoning organisms are also under study: the factors affecting growth and toxin production by *Staphylococcus aureus* are being investigated. Nitrite inhibits the growth of *S. aureus* under anaerobic conditions in sausage products; spices enhance acid production in fermented sausages, producing more quickly a pH unfavorable for growth of *S. aureus*.

A closely related study is designed to discover how nitrite functions as a bacteriostatic agent. It has been suggested that it attacks sulfhydryl groups on an enzyme in bacterial membranes. Electron microscopy has shown that cellular membranes of the common food-spoilage organism, *Clostridium perfringens*, are changed by the action of nitrite and that cell division is inhibited. Spectroscopic studies (primarily laser-Raman and infrared) are designed to discover exactly what happens to the membranes. As understanding of the action of nitrite unfolds, prediction of alternative methods of food preservation are sought. Preservation has always been an important activity of agriculture but has become even more significant.

The current methods for determining meat quality, especially meat tenderness, are not highly reliable. These include visible inspection of marbling, penetration tests, and various shear tests on cooked meat samples. Ultrastructural characteristics (revealed by the electron microscope) and mechanical properties are being studied to determine if definable features of the muscle system can be used to develop alternative methods for assessing meat quality. Under investigation are the fat-muscle fiber structural relationships in raw and cooked meat, the influence of different feeding methods, and the influence of different ways to cook and prepare the meat.

Among the beneficial functions of sodium nitrite in processed meats is its ability to prolong the shelf life by retarding oxidative rancidity. Although some derivative of nitrite rather than nitrite itself is generally accepted as the active agent, there is a need to know the nature of the active antioxidant and its mode of action. The present research is intended to supply this knowledge so that an effective substitute for nitrite can be selected or devised.

Energy-Related Research

One program is directed toward conservation of energy in food processing, namely, low-energy concentration of heat-sensitive liquid foods. This project is jointly funded by USDA and the U.S. Department of Energy. Its objective is to study various combinations of reverse osmosis, freeze concentration, and thermal evaporation to determine which optimal combination will use minimum energy without sacrificing product quality when concentrating heat-sensitive liquid foods. Work will be done with skim milk (because it is presently concentrated in large volumes and contains protein and a sugar of low solubility) and a fruit juice (because it contains volatile flavor).

Dehydrated foods may become increasingly important as a result of energy shortages because they offer energy-saving advantages over the fresh and frozen varieties in the areas of shipping, distributing, and storing. Until now, the quality of dried foods, except the expensive freeze-dried products generally has not been completely acceptable. The ERRC is now completing work that began as a concept for producing dry fruit and vegetable pieces (slices and dices) that are of good quality and have porous structures. The process, known as explosive-puffing is commercially feasible since the design and construction of a continuous puffing apparatus. As a result, several food processing companies have shown great interest in adopting this concept as one of their developments.

Plant Science Research

An example of ERRC research aimed at protecting the consumer from natural toxicants is the ongoing work on the glycoalkaloids of the potato. Two glycoalkaloids, α-solanine and α-chaconine, are natural toxicants present in commercial potatoes at levels that apparently do not represent a hazard. However, the margin of safety between the level at which glycoalkaloids occur in the potato and the level at which symptoms of toxicity would be experienced by some consumers is comparatively small.

Potato breeders have been greatly concerned about the level of glycoalkaloids in new varieties. The concern is based on two situations: first, a variety (Lenape) was introduced and later withdrawn that contained levels of glycoalkaloids incompatible with human health; and second, it is becoming understood that new varieties of fruits and vegetables will not be considered acceptable if the level of natural toxicants is significantly increased by breeding or selection over the levels in existing varieties. The ERRC research team developed two methods for determining the types and amounts of glycoalkaloids in potato tubers. The first, a simple nonaqueous titration, gives a reliable measurement of total glycoalkaloids in a sample; the second, a gas-liquid chromatographic procedure, provides separation and quantitation of the two major glycoalkaloids of commercial potatoes (*Solanum tuberosum*) plus about 10 other glycoalkaloids present in other *Solanum* species including wild potatoes used for breeding purposes. These methods are now widely used by potato breeders around the world to follow the glycoalkaloid content of breeding lines, new varieties, and commercial potatoes.

Research is also in progress on host-pathogen interactions. Electron and light microscopy are used to determine how pathogens breech a plant's defense systems. Examination of these attack points suggests that complex enzymatic processes have been initiated on the part of both the pathogen and the host. Some of our studies are devoted to better ways of separating and identifying these enzymes. Researchers at ERRC and elsewhere are studying the chemical compounds expressed by resistant or susceptible cultivars and their relationships to plant survival. It is possible that new compounds for preventing plant disease could result from such studies. More importantly, the research provides new insights for plant breeders and gives them a new method of breeding for specific antipathogenic properties.

Acknowledgment

I would like to thank laboratory chiefs N.C. Aceto, D.D. Bills, S.H. Feairheller, G. Maerker, H.L. Rothbart, A.E. Wasserman, and J.H. Woychik for their contributions; M.M. Krider, program analyst, for help with Figs. 1–4 and Assistant Director E.E. Alt, Jr., for coordinating this review.