Chapter IV

PROCESSING AND PACKAGING TECHNOLOGIES FOR ASSESSMENT

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The processing and packaging technologies that the Office of Technology Assessment (OTA) considers of highest priority for assessment are listed (in priority order) in table 3. The list emphasizes those technologies with a strong probability of early occurrence and significant expected impacts. Given highest priority were those where the probability of adoption is considered high and that would be expected to have considerable impact if adopted. Technologies where probability of occurrence by 1985 is considered high but with moderate impacts or technologies where impacts are expected to be high but probability of adoption is considered low were given lower priority.

OTA staff ranked the technologies based on the information developed in the workshop and by collateral staff work. Detailed workshop discussions provided much of the information on impacts and issues for each technology and brought out additional points on development and adoption that aided in placing a general priority order for intended technology assessments on each of the technologies. (See appendix D.)

Technologies in this chapter have been divided into the following classifications: preservation, new and improved equipment and processing techniques, new and modified food products, new sources of ingredients, and packaging.

Processing is one of the series of operations performed on a product that aids preservation, makes it more convenient to use, produces a new food form, produces an ingredient for use in further processing, or produces a more palatable food. The number of plants and employees engaged in food processing is shown in table 4 under five broad classifications for 1963 and 1972. These data show the total size of the food processing industry and that the plants are becoming fewer and increasing in size, since the total quantity of foods processed has increased. Data for 1975-76 show that the top 100 food processors had food sales of almost $16 billion.[1] Total industry shipments of food and beverages, including imports, totaled about $193 billion.

Almost 4.4 percent of U.S. energy output is used in manufacturing food and kindred products, with about one-half of this consumed in the production of processing inputs. (The estimate may be conservative, as energy consumed on many capital inputs could not be estimated.)[2]

[1] "The Top 100 Food Companies," *Food Processing*, December 1977.
[2] *Energy Consumption in the Food System*, prepared for the Federal Energy Administration by Booz, Allen, and Hamilton, Report No. 13392-007-001, December 1975.

Table 3.—Processing and Packaging Technoiogies With High Priority for Assessment

Technologies with high priority of adoption and high impact
1) Fabricated foods (p. 42)
2) Retort pouch (p. 46)
3) Recyclable and returnable containers (p. 47)

Technologies with high priority of adoption and moderate impact
1) Aseptic processing and packaging (p. 35)
2) Development of new sweeteners (p. 43)
3) Conversion of waste to human food and animal feed (p. 44)
4) Central cutting and packaging of meat (p. 37)

Technologies **with low** probability of adoption and **high impact**
1) More efficient water utilization (p. 38)
2) Irradiation (p. 36)

Table 4~.—Number of Plants and Employees for Food Processing

Type plant	Number 1963	Number 1972	Employees* 1963	Employees* 1972
Dairy products. . . .	7,885	4,590	257”	189
Meat packing.	5,300	4,437	300	308
Bakery	5,366	3,633	280	235
Canning & freezing	3,969	2,557	245	233
Grainmill products	3,555	3,080	113	111
Total	26,075	18,297	1,195	1,076

“ Number of employees In thousands
SOURCE Olan D Forker and James L Pearson, The Food and Fiber Market System — Its Magnitude and Contribution,' speech presented at a workshop on Coordination of Market Research, May 9 1977, Washington, D C

PRESERVATION

One major aim of processing is to extend the storage life of foods through preservation techniques. Some methods preserve food in a state near the fresh form, while others produce drastic changes in shape, taste, and other characteristics, Preservation may change the form of the food very little, as in freezing, or completely, as in making cheese. Regardless of the end purpose of processing, preservation is a part of any process where the product is to be stored.

Preservation is not limited to the processing function; even fruits and vegetables to be sold fresh are handled by processing equip ment designed to minimize bruises. In same cases special washes and controlled-environment storage are used to aid preservation.

The principal techniques to extend shelf life and retard spoilage are those that act to remove or destroy potentially harmful micr~ biological organisms or suppress the activity of micro-organisms. Adverse changes in foods [spoilage) are caused by micro-organism or enzymatic activity, chemical reaction, or such physical or physiochemical changes as drying or crystallization. Microbial spoilage is the easiest to control, enzymatic conversions are more difficult to prevent, and chemical reactions are almost impossible to completely suppress. Techniques fall into three categories: removal, destruction, or suppression.

Removal may be accomplished by filtration when the product is water-soluble, and in certain instances by centrifuging, Such techniques generally must be combined with other methods in order to be effective,

The most widely used and effective technique for destruction of micro-organisms is heating, the only negative result of which is that beyond certain temperatures the quality of the product may be affected. Radiation is another method, although it may, at high levels, cause undesirable chemical reactions.

Other than destruction through heating, suppression of microorganic activity is the most prevalent method of preserving and increasing the shelf life of foods and food products. Techniques for suppression include cooling (refrigeration), freezing, and reducing water content. Freeze-drying, a method gaining acceptance but with economic disadvantages still to be overcome, combines the latter two techniques. Suppression by additive is a method used extensively in food processing, The additive generally changes the native characteristics of the food or food product—for instance, jellying, curing, and pickling by adding sugar or salt; fermentation; stabilization by adding alcohol or acid, In addition, such chemical or biological substances as preservatives or antibiotics may be added to a product to act specifically against microorganisms.

Modifications to and combinations of these preservation techniques are constantly being developed, and several specific processes, such as freeze-drying, that offer potential for greater use, are discussed in this chapter.

Aseptic Processing and Packaging

Aseptic processing brings together a pasteurized or sterilized product with a sterile package in a sterile environment, The process may be classified into three technologies: 1) ultra-high {temperature (UHT) pasteurization of liquids, combined with aseptic packaging, 2) aseptic canning of particulate foods such as fruits and vegetables currently frozen or canned, and 3) aseptic bulk storage of products.

Milk is the most common liquid sterilized by UHT processing and combined with aseptic packaging. The product will keep for several months without refrigeration and is currently available and used in many countries where refrigeration is at a premium. After opening, the product has to be refrigerated. It is being commercially marketed in Canada and test-marketed in the United States. Recent reports indicate that acceptance of the product in Canada has not been as good as expected, with flavor being the major problem. In addition to taste, the total energy use of this system must be assessed in relation to that used by other available systems.

Technologies are being developed that will permit heat sterilization of particulate foods so they can be aseptically canned. However, these technologies are not yet commercially developed. Presumably the products would be superior in taste and nutrition to conventionally retorted foods. Currently, only puddings and other nonparticulate foods are aseptically canned.

Aseptic bulk storage has been used for holding vegetables at field locations and in plants for further processing, Products have also been stored and shipped in aseptic rail tank cars. This method shows promise for overcoming some of the difficulties associated with products that must be harvested and processed in a short time, and it will have its greatest application in high-acid foods.

This discussion focuses primarily on the UHT pasteurization of milk in aseptic packages. The technology is currently in use and offers some concrete possibilities for an improved milk processing and distribution system, provided the taste of the product is made acceptable to U.S. consumers.

If widely adopted, the system would probably have a great impact on the production, processing, and distribution of milk. The impact is considered moderate, however, in that it concerns only one product and would not substantially affect the entire marketing system.

A smaller dairy herd would be needed for a given level of demand, since the long shelf life would permit carrying milk produced in the flush season over into succeeding months, when seasonal declines in production take place. Interregional production might be affected—for example, more milk might be produced in Wisconsin and less in Texas than at present. This also raises the possibility that producing and processing firms would become more concentrated and that smaller miik producers and distributors would be at a competitive disadvantage.

Distribution charnels would also be affected, since UHT milk could be handled in regular warehouse channels rather thari as a vendor item (such items are delivered frequently and on a regular basis to individual stores). This would have implications for labor contracts and potential shifts in labor concentration from drivers to warehouse workers or other occupations.

Consumers spent about $12.1 billion for fluid milk and cream in 1976. Because of the size of the industry, the fact that some cream is currently aseptically packaged, and the severity of market disruptions likely to occur, the first assessment of aseptic packaging should be on fluid milk and cream.

When technologies are developed that permit aseptic processing and packaging of solid foods, the impacts of these would need to be assessed relative to other technologies such as the retort pouch.

Bulk storage and transportation of fruits and vegetables would impact primarily on the processing and transportation system. The processing of fresh produce is now constrained by the period of harvest, and aseptic bulk storage would permit better and more flexible scheduling of processing operations, better utilization of facilities, possible decentralization of final stage processing, reduction in processing and transportation costs, and better utilization of the processing labor force.[3]

Bulk storage would cause relocation in labor, would require an upgrading of the rail transport system, and could result in better utilization of energy in transportation.

Irradiated Foods

Irradiation involves the exposure of foods to certain ionizing radiations—namely, either gamma rays or electrons. Irradiation is sterilization without heat and avoids many of the problems encountered with the use of heat. Foods sterilized by irradiation can be stored at room temperature indefinitely.

Irradiation of foods offers considerable potential for the preservation of products where refrigeration and other preservation methods are limited. Currently, food irradiation is approved in many Western European countries for extending the shelf life of certain perishable products, for controlling ripening of fruit, and for inhibiting sprouting of potatoes, and has been approved in this country for limited use to control sprouting of potatoes in storage and to eliminate insects from wheat. Irradiation significantly reduces the levels of nitrate and nitrites required to maintain color in cured meats. Currently, a variety of shelf-stable meat and poultry products superior to thermally canned products has been developed and could be made available to consumers when the Food and Drug Administration (FDA) approval is received.

There are two irradiation procedures for purposes of preservation: 1) low-dose irradiation used for pasteurization or in combination with another technology to prolong shelf life; or 2) high-dose irradiation to produce a shelf-stable product. The probability that shelf-stable foods produced through high-dose irradiation will be used extensively in the near future appears remote. Should it occur, the military would probably be the first user.

While there is considerable potential in this process, several obstacles must be overcome before this will become significant. Irradiation is defined as a food additive, therefore bringing it within FDA's jurisdiction, and each irradiated item must be proven wholesome. Irradiation may also cause undesirable chemical changes in foods. A potential obstacle to overcome is the public's possible apprehension about radiation. Although real progress has been made in the irradiation of food, the technology does not appear ready as a major method of preservation until the wholesomeness and safety questions have been resolved.

This technology has a low probability of occurrence but will have considerable impact if adopted. The implications for the food marketing system and the safety issues of concern to consumers place this technology high on the list of technologies expected to have strong but negative impacts.

Lowdose irradiation has the best chance of near-term adoption. The shelf life of products could be extended with the possibility of reducing loss in the distribution of food. Low-dose irradiation in combination with other methods of preservation, such as refrigeration, may offer the greatest chance for success.

High-dose irradiation produces shelf-stable products and would impact on the total marketing system. Consumer concern over the safety of the product from the irradiation process is an issue. If the process becomes economical and irradiation becomes a major method of food preservation, firms processing canned, dried, and frozen foods would be affected.

[3]"Purdue and Bishopric Share IFT's Industrial Award, " Food Technology, June 1976,

Freeze-Drying

Freeze-drying is contact drying which takes place at such a low vapor pressure that the temperature of the water drops below the freezing point. Freeze-dried products shrink very little and retain their original shape and much of their flavor.

For purposes of discussion, freeze-drying is divided into two technologies: freeze-drying combined with compression, and new methods of freeze-drying. Freeze-drying combined with compression will probably not be widely adopted by 1985, but it ranks about in the middle of all technologies based on impacts, with the negative about equal to the positive. When freeze-dried foods are compressed, the reduction in volume is from 4 to 2o times, saving space in storage, shipment, and display.

This process is currently in limited use. A big disadvantage has been its high cost; another is the large amount of energy the process uses. This is one reason for the search for new methods of freeze-drying. Currently, a method for gaining the volume-reduction advantages of compression without the need to use conventional freeze-dried starting materials is being evaluated, These methods have changed, but there have been no dramatic technologies to change the basic cost picture. Because of the high quality of the product and the potential for saving in transportation and marketing costs throughout the system, research is needed to find new methods that will lower the cost,

The major issue surrounding this technology is whether the process will become economically feasible. There are no known health hazards associated with the product. The technology is capital-intensive and, as with many such technologies, could increase concentration in the industry.

NEW AND IMPROVED EQUIPMENT AND PROCESSING TECHNIQUES

These technologies replace a present technology with little or no resulting change in the product but with a saving of inputs such as energy, labor, or water; a reduction in pollution; or an increase in output with less waste from the same quantity of raw material. Technologies that enable greater line speed in processing or reduce the degree of heat or time required in canning would be examples. Caustic peeling of fruits and vegetables reduces water consumption and waste in processing. Redesigning the washing equipment in poultry processing plants reduces water consumption and loads on the processing systems. New visual or electronic technologies for checking quality of food products fall in this classification.

Central Cutting and Packaging of Meat

In 1977, expenditures for beef were 2.1 percent of disposable consumer income and 4.5 percent for expenditures on all red meat (which includes beef, pork, veal, lamb, and mutton). Red meat accounts for 25 percent of the consumer food dollar. Any technology that would reduce meat marketing costs could have a significant effect on consumer income.[4]

Central cutting of beef involves cutting the carcass into smaller units before the beef is moved to retail outlets. An estimated two-thirds of the beef entering supermarkets in 1974 were broken down from the carcass.[5] This included beef precut at the packing plant, at wholesale centers, and at retail chain warehouses. There are different combinations of procedures and technologies. Boxed beef—where the packer breaks the carcass into primal cuts, vacuum-packs them,

[4] U. S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, Livestock and Meat Situation, LMS-219, Washington, D, C., February 1978.
[5] John W. Allen, "A Look at Trends in the Meat Industry, " 1975. Paper presented at the Supermarket Institute Convention Workshop, May 6, 1975.

and ships them to the retailer in boxes—is about one-fourth of the movement to retail stores. Other combinations of technologies in systems generally involve retail store facilities or local wholesalers,

Central cutting and boxing of beef is felt to be economically feasible, and it is possible that opposition from labor unions has kept it from more widespread use. A recent U.S. Department of Agriculture (USDA] publication supports the contention that it is more economical to cut beef into retail cuts at central locations. The report, however, points out that present "boxed beef" is not the most efficient method and that in fact in some situations the more traditional methods of cutting the carcass at retail maybe more efficient.'

In view of the many differing systems and combinations of technologies involved in central cutting of beef, each major system should be assessed separately.

The health and economic impacts may be quite different between systems. Dr. Robert Angelotti, formerly of USDA, indicates that research is under way in the Department to determine the degree of contamination in beef cut in primals and vacuum-packed at central locations. Preliminary findings indicate that, ". . . vacuum-packaging of beef draws a purge of the body fluids which collect in the bottom of the bag and support a very different kind of microbial flora from that which is supported when meat is dry-hung in a refrigerator. Because the product has a 60- to 90-day shelf life in distribution, the organisms grow in the bottom of that bag and contaminate the muscle fibers which are separated, creating internal contamination which would not have happened if the meat had been hung dry."*

Appropriate questions may not have been asked during the development of this technology concerning product contamination as a result of this practice. The problem is not one of central cutting but of the type of packaging and the length of time the meat is held. It is critical to assess potential changes in the safety of the meat in relation to any change in the procedure for cutting and packing.

Central cutting of beef may impact on other areas as well. The number of meatcutters needed could be reduced, or relocation of workers might result as more meat is cut at central locations. Central cutting of beef into retail cuts raises the potential of loss at retail if the demand from day to day is not as expected. Once packaged as retail cuts, the meat must be sold within a limited time, although this could be up to 7 days if the meat is handled in a sanitary manner and stored at the proper temperature. Frozen retail cuts would eliminate this problem but world add t. the cost and in most instances meet with consumer resistance. The effect on energy consumption of a shift to frozen beef would be an important consideration.

More Efficient Utilization of Water in Processing

This is an area of technological need rather than of specific technologies. These technologies could reduce the amount of energy used in processing plants and the pollution from them. The probability of successfully developing these technologies is low, although specific technologies have been developed to reduce water consumption in poultry processing plants and in fruit and vegetable processing and packaging operations.

The positive impacts of these technologies would be on conservation of water and energy, resources expected to be scarce in the future; thus the impact of such technologies, should they be adopted, is considered high, since processing of most food products consumes vast quantities of water. Water-conserving technologies are not expected to raise many negative issues, but technologies that recycle water raise the possibility of contamination and associated health issues.

One needs to define the processes where water consumption is high and then determine what, if any, action is needed to encourage development of water-saving technologies.

[6] L.A. Deuwer and T.L. Crawford, Alternative *Beef* Handling Systems, Economic Research Service, USDA ERS-661, report from AER, Vol. 29, No. 3, June 1977.

*Working Group Proceedings on Emerging Food Marketing Technologies, Oct. 4, 1977, p.237.

Analytical Instrumentation and Processes for Detecting Ingredients in Foods

A technological process or series of processes that will identify ingredients in food plays an important role in food processing and safety. It need not be restricted LO a single ingredient and is obviously needed to detect toxic substances in food. This technology could complement the conversion of waste to food, where a major copncern is the safety of these foods and the kinds of residues that might be present.

Instrumentation of the type that will speedily and accurately detect ingredients in feed could have a positive effect in monitoring the processing and fabrication of certain foods because it would be capable of identifying not only toxic substances but also moisture, fat, and ai protein content.

Instruments capable of monitoring processing lines would provide a means of checking fabricated foods for possible toxic substances or contaminants and ingredient con tent. They would, therefore, be a positive influence on the development of, and possibly remove much of the concern about, the ' 'unknowns" in ersatz or fabricated foods.

The adoption of this instrumentation will add impetus to the existing policy dilemma of acceptable to!erance levels of certain additives, toxic substances, and carcinogens in food.

Microwave Ovens and Special Packaging

More than a quarter of the homes in the United States are expected to have microwave units by 1980. Available data projects over 6 million units in almost 10 percent of the homes in 1977. This trend could accelerate, since microwave cooking has been shown to save up to 70 percent of the energy in home cooking of some foods.

Microwave cooking in the home is compatible with convenience foods and fits in with the changes in lifestyles already under way such as the desire to spend less time in home preparation of foods,

Rapid expansion m the home use of microwave energy impacts on a number of areas, raises issues unique to home use of microwave energy, and reiates to other issues that are part of changing lifestyle.

Improvements have been made in design and production procedures of these units to prevent leakage of radiation. The issue is not completely dead, however, and consumers may resist buying microwave appliances or raise new issues associated with safety.

The rapid increase in home use of microwave ovens has spurred the development of new food formulations and packaging specially designed for microwave cooking, such as new paper trays and Ceramic containers spe~- cially designed for micrcwave or conventional oven use. Allthough it was developed as an answer to the speedy preparation of convenience foods, microwave cooking may in turn encourage the consumption of more convenience foods. This could mean more packaging and a consequent increase in energy use. Also, the effect of increased consumption of highly processed foods on nutrition and health should be considered.

If microwave units substitute for rather than supplement conventional ranges, there will be an impact on stove manufacturers. Many microwave units are built in foreign ccuntries and many electronic parts for 'J. S, makes are foreign products, This may contribute to an unfavorable balance of payments at a time when there is a deficit. Microwave units use less energy, therefore energv use may decrease, and there may be possible savings in home wiring compared to conventional ranges due to the decrease in energy needs.

Aquaculture

Aquiculture as used here refers primarily to the systematic cultivation of animal life in a water environment (in a broader sense it could also include plants). Catfish farming in the South is one example of aquiculture; crawfish, salmon, trout, and other fish are also produced this way, Recent experiments and pilot projects show promise for farming shrimp and other species.

Economics may discourage widespread expansion in the United States through 1985, although catfish and other species have been well accepted. Aquiculture could, however, make a positive contribution to the food supply and nutrition status were it to become more widespread. (One problem has been consumer acceptance of many species of fish and fish products made by aquiculture methods.)

Development of aquiculture is expected to evolve slowly, and the impacts on resource adjustments should be minimal. Technologies are needed to lower processing costs and more efficiently utilize the marine animals produced. Marine products are subject to contamination and spoilage, and new methods are needed in processing, preservation, and storage to minimize spoilage.

In some locations, toxic substances such as mercury have accumulated in fish at levels in excess of State or Federal levels established to protect human health. When this occurs, consumption of the contaminated fish is banned in the affected area, with an adverse economic impact on those directly involved. In aquiculture, the economic effects of such contamination would be more widespread and severe because of the large amounts of capital invested in the growing operations and processing facilities.

Solar Energy in Processing

The concept of solar energy as a technology in food processing includes dehydrating food with solar energy as well as utilizing solar energy to supply heat and power for processing operations. The U.S. Department of Energy (DOE), (formerly the Energy Research and Development Administration), is supporting a number of projects on the feasibility of solar energy in industrial heat processes, including heating water for washing food cans. Other studies are investigating the feasibility of using solar energy in industrial drying and dehydration, including prunes, soybeans, and onions.[7]

Unless a technology is developed that applies solely to food processing, specific impacts on food processing would be those associated with all processing plants, such as choice of location and level of energy requirements.[a] That is, conversion to solar energy in food processing would impact on energy suppliers in much the same way as conversion to solar energy in any large industry if the power from solar converters were supplied from central powerplants. If technology were developed that permits onsite generation of solar power, however, large firms would probably be able to convert before smaller firms and thus gain the competitive advantage. Large processing plants might also be more able to locate in areas with high probability of clear, sunny days.

Initial Preparation of Fruits and Vegetables in the Field

Much packing of fruits and vegetables is already done in the field. The original concept was to reduce the amount of waste produce shipped and to reduce work and pollution at the receiving site.

One facet of this technology that concerns loss prevention involves packing in bins that could be moved untouched through the system to retail outlets. Technologies for improved packing methods, better shipping containers, and controlled-atmosphere shipping should be considered. Aseptic bulk storage and transportation of processed tomatoes is an existing system that has potential for greater use. Waste is left at the production site, and the product is held and transported to a central point for further processing.

According to participants in the working group, these technologies have a high probability of adoption. The impacts will probably be positive. However, more information is required to determine which technologies may be the best under given circumstances, considering waste, cost, consumer preference, and other impact areas. For instance, bulk handling may be best for local and inter-

[7]U.S. Energy Research and Development Administration, Solar Energy *for* Agricultural and Industrial Process Heat, Division of Solar Energy, ERDA 77-72, Washington, D. C., June 1977.

[a]A comprehensive discussion of solar energy is found in Volume I, Application *of Solar* Technology to Today's Energy Needs, Washington, D. C.: U.S. Congress, Office of Technology Assessment, June 1978.

mediate distances, while some produce should be shipped in consumer packs with extensive secondary packaging. (See chapter II, Technologies to Reduce Food Loss.)

Mechanical Deboning of Beef

While poultry has been mechanically deboned for several years, approval for mechanically deboned beef (the bone and meat are pulverized together and the meat than separated from the bone particles) was withdrawn after objection by consumer groups. They did not appear to oppose the ccncept of mechanical deboning but wanted the label on the end product to clearly indicate that it contained mechanically deboned meat. The consumer groups were also concerned that meat deboned mechanically was more prone to bacterial contamination and would contain a small amount of pulverized bone. Consumers worried about the lack of information on the effect on health of increased intake of calcium from these bone particles.

USDA has proposed a new regulation requiring that the product be labeled as "mechanically deboned [type of meat) product,'' which wou!d require that there be not more than 20 percent of a meat-and-bone mixture in the product and placing certain other restrictions on use of the product. There were objections from the industry and others to this new proposal, which was then revised by USDA, Consumer spokesmen have questioned the research data attesting to the safety of the product, and industry groups have objected to the proposed name. Nevertheless, the regulations became effective in July 1978.

This particular technology and the opposition to its adoption underscore the need to include consumer concerns in the regulatory process and to accurately identify where the benefits will occur or where the disadvantages will be felt.

Mechanical deboning of beef will provide more edible beef or less waste from a carcass. The impact on producers is not clear; more edible products from a carcass make it more valuable, but better utilization of this technology would increase supply and depress prices unless new products were developed that would increase demand,

Major issues or concerns are product quality and the effects of long-term ingestion of pulverized bone. The labeling of mechanically deboned meat called for by consumers is a specific example of a labeling issue common to many ingredients derived from byproducts and waste.

This technology exists and is used today. The regulatory issue of ingredient labeling and the implications of this product on food safety, health, and nutritional status are serious concerns, as is its economics versus alternative deboning technologies.

Hot-Boning of Beef

Hot-boning of beef involves cutting the carcass into primals and removing the bones before the meat is chilled. This technology is considered to have a low probability of widespread adoption with relatively high negative impacts.

Advantages claimed for the technology are reduced energy costs for cooling, less space needed for storage, and less waste to ship. However, hot meat is claimed to be more difficult to cut than cold meat, and the change is resisted by the meatcutters, although this allegation has not been documented. In addition to energy and transportation aspects, health and safety, because of the possibility of contamination of the beef during hot-boning and associated procedures, are important societal issues.

Moisture Reduction Processes

Technologies exist that can dehydrate foods or reduce their moisture content (producing intermediate moisture foods) through one or a combination of treatments. The aim of these technologies is to produce a shelf-stable product.

New dehydrated foods are being produced through new applications or modifications of the drying processes. Vacuum foam-dried milk is one example. Another is continuous explosion puffing, a new system developed for processing fruits and vegetables which could substantially reduce preparation time and save energy.

The aim in producing intermediate-moisture foods is to reduce the water activity so the product will be shelf-stable yet have a moisture content higher than dehydrated products. A number of technologies are available that will produce intermediate-moisture foods such as fruitcake. The most common method decreases the water content and then infuses the product with soluble salt and sugars This changes the flavor and texture of the product, and consumers may consider some products to be of inferior quality.

Other possible techniques include reducing water activity and then applying a mild heat treatment. 'i'he immediate impact of this process could be to reduce energy use throughout tlie food marketing system, but these possibilities have yet t. be explored commercially.

If more foods are made shelf-stable through moisture reduction processes, this would imply some change in consumption habits, For consumers it would mean less need for freezer or refrigeration capacity with a corresponding saving in energy. If foods infused with salts or sugars become a significant part of consumers' diets, iheir impact on health and nutrition must be considered.

Dehydrated or partially dehydrated foods mean a saving in transportation and also in storage space. Energy needed for storage would be less than for frozen or refrigerated foods,

NEW AND MODIFIED FOOD PRODUCTS

These products genera!ly have been designed, engineered, or formulated from various ingredients including additives. They are made by structuring, texturing, shaping, or blending ingredients and in most instances use a combination of technologies. They may be made to resemble traditional items, they may be new forms of snack foods, diet foods, or other products, or they may be a new substance used as one ingredient in an otherwise traditional food product, such as non-caloric sweeteners.

The nutritional value of new and modified foods and ingredients depends on their formulation and may be nutritionally equal to or quite different from the food for which they substitute.

Fabricated Foods

The marketing of engineered or fabricated foods is widespread and will increase. Sales of engineered foods were more than $6 billion in 1972 and are expected to exceed $11 billion by 1980.[9] These are important technologies with important policy implications; for instance, vegetable protein, a major ingredient in engineered foods, has a high probability of increased use as a meat extender and to a lesser degree as a substitute for meat by the year 2000.

Fabricated foods include many dairy substitutes such as coffee whiteners, toppings, whey-soy blends, imitation cheese, and imitation milk drink. Meat substitutes include fabricated ham and sausage and steaks engineered from flaked meat and textured soy. (Soy protein is the major ingredient in fabricated meat and soybean oil in dairy products.) Other fabricated foods include substitutes for eggs and citrus products.

Fabricated foods fall into two categories, analogs and ingredients, which should be discussed separately. Analogs are those foods

[9]In 1976, fabricated dairy substitutes such as coffee whiteners and toppings had sales of $1 billion. Fabricated snack foods such as chips had $2.5 billion, fabricated cookies and candy had $1 .'7 billion, vegetable protein had $35o million, and fabricated beverages had $212 million.

fabricated to resemble a specific food in taste, texture, and color. They include complete substitutes foi' meat 1, synthetic drinks, and such substitute dairy produsts as cheese, coffee whiteners, etc. Ingredients refer to extenders, fillers and emulsifiers intended, for example, to replace part of the ground beef in a hamhurger with soy or to extend natural chocolate with a substitute These definitions are not mutually exclusive: in some instances, textured soy might totally replace ground beef and become an analog,

Although the level of use will determine the degree arid severity of impacts these products wi!l have on lhe marketing system, several general advantages of fabricated foods are the possibility of lower focal costs, extended food supply in times of shortage, better control of nutrition, better utilization of products, and reduction in energy use.

Many impact and issue areas are common to a large number of fabricated products, while other products raise issues unique to themselves. In general, fabricated foods raise issues of food safety, consumer acceptance, nutrition, and labeling: and specific fabricated foods raise suc]i issues as resource use and effect on the agricultural marketing system.

Food safety is an issues with many fabricated foods because they use a number of ingredients and additives for which different standards and regulations exist on which there is frequent disagreement. Some segments of the food system feel that the standards are restrictive and discourage the development of new foods, while others fee! consumers are not adequately protected from the effects of these ingredients and additives.

The nutrition issue depends to a great extent on the specific foods, their intended use, and how they are formulated. For example, vegetable protein extenders that substitute for only a fraction of protein intake are of less concern than a meat analog that would substitute for all or a major part of protein intake and would not raise the same nutrition issues. The FDA has proposed different nutrient standards for analogs and meat extenders.

At issue also is the proportion of our intake that might eventually be from fabricated foods and tbe effect on nutrient content of our total diet. On the other hand, fabricated foods may be formulated to supply special dietary needs or fortified to improve inadequate diets of selected population groups.

Tastes change slowly, and for fabricated foods to gain cofisumer acceptance they are manufactured to resemble the food for which they substitute. How should these foods be labeled to properly identify them and yet not present acceptance barriers'? This is a labeling issue in food service operations, where consumers may not know they are eating a hamburger extended with soy protein or meatloaf containing a vegetable protein extender. The latter is already in use.

Extensive use of fabricated foods affects agricultural resource use. The increased consumption of margarine, for example, has decreased the demand for butterfat, affected the dairy industry, and necessitated new policy decisions. The substitution of soy for animal protein can be expected to raise similar issues.

Two fabricated products that will raise many of the issues cited above and that are highest on the list for assessment include soy protein as both analog and extender for meat products and imitation cheese fabricated from vegetable oil and other ingredients,

New Sweeteners

Since a major health and nutrition concern in the United States today is obesity arid increased sugar consumption, there is strong incentive (economic and nutritional) to develop and produce new low-caloric sweeteners for use in food processing and the production of diet foods.

Some low-caloric sweeteners exist, and it is felt that the search for others will continue. Xylitol, an extremely potent sweetening agent made from the rhine of grapefruit, has fairly specialized uses; others would have wider applications. New corn sweeteners have been developed that, although they produce the same sweetness level with fewer calories than other sugars, do contain calories in some uses.

The only legal non-caloric sweetener on the market today is saccharin. The recent controversy over the use of this substance may have sparked some of the current interest in developing new sweeteners. Currently, saccharin labeling regulations require that foods containing this substance carry a warning of its possible hazards. This restriction will be carried for 18 months, at which time the safety question will be reevaluated. The outcome of this review may well determine the future use of other such sweeteners.

There is preliminary evidence that xylitol is a carcinogen. It is different from other sweeteners, such as cyclamates and saccharin, in that it is a naturally occurring sweetener. A closely related compound, xylulose, is produced in the body during normal metabolism; and there is a potential, through one simple chemical reaction, for the formation of xylitol from xylulose in small amounts. This issue of carcinogenicity, mainly related to the zero-tolerance levels established by the Delaney amendment to the Food, Drug, and Cosmetic Act, raises the very important policy question concerning the use of massive doses in animal testing for carcinogens.

The safety of any newly developed non-caloric sweetener will be a major issue, particularly concerning the type and length of tests undertaken before and after approval. An assessment of a new sweetener should go beyond the health issue, however, and assess the markets likely to be penetrated, the effect on total intake of different sugars, and the consequences to the processing industries. The cost of particular forms, whether liquid or solid; the sweetness; and other functional characteristics determine market use. Corn sweeteners have captured significant portions of the cane and beet sugar markets, with repercussions to domestic and foreign producers; and new sweeteners are expected to cause similar impacts and raise similar policy issues concerning support prices and import quotas.

NEW SOURCES OF INGREDIENTS

New technologies have resulted in new sources of ingredients for use in food processing. New methods of crushing combined with centrifuging now permit production of edible protein from cotton seeds. Certain membrane processes allow for the separation of edible protein from whey. Solvent extraction and texturizing give a variety of soy protein products. Processes using enzymes produce high-fructose corn syrups and other corn sweeteners. Single-cell organisms produce protein from a variety of processing wastes and other sources.

Conversion of Waste to Food and Feed

Research and development should continue on a wide range of processes to convert waste to edible products or feed and to better utilize agricultural production.

The first problem is defining waste. What is considered waste under one set of conditions may be considered a food under other circumstances. For example, whey is a waste if there is insufficient volume to justify the fixed costs required to purchase equipment that will convert it to edible protein. Additional economically feasible processes could produce useful products from wastes such as fruit and vegetable pulp and peelings and animal byproducts, which would reduce food losses in the marketing system.

Because of the different course materials and different technologies, there could be many different issues, However, in a discussion of waste conversion, three issue areas emerge: 1) getting approval as food products, 2) labeling for consumers, and 3) consumer acceptance.

Under the regulatory procedures in effect today, approval will be difficult to secure for foods generated from many wastes. The scientific base regarding the effects of toxin concentration in waste recycling is not very well known. The degree of difficulty depends in part on the source material; utilizing waste from a food product would not be expected to generate as many problems as converting a traditional nonfood waste to a food. Possible wastes mentioned for conversion to food or feed include vegetable pulp and peel, blood from animal slaughtering, waste from seafood processing, and trash fish. * Vegetable wastes would probably have fewer problems in product approval than many other wastes but could have problems due to possible residues on the pulp or peel.

Labeling the products presents another area of concern to consumers. The possibility of using a plasma fraction from blood collected during animal slaughtering as a functional ingredient or binding agent is a case in point, Labeling the ingredient as blood would probably discourage consumer acceptance. Should the product be labeled as to specific origin or just by the final ingredient name? This issue will be common to many of the food products produced from waste materials.

Consumers may reject many of these foods or food products, even when the foods have been approved, because of custom, taste, fear, or a number of other reasons. A factual, straightforward consumer educational program prior to the introduction of these new foods would give consumers a more rational basis for accepting or rejecting these products.

*Trash fish are any of various sea fishes that have no market value as human food but may be processed for oil or meal for domestic animals.

This entire area offers possibilities in the years ahead for providing more food and for alleviating pollution; however, there are many problems and many issues.

Processing Using Single-Cell Organisms

Agricultural waste can pollute, and because of this considerable research has been conducted on using single-cell organisms to convert these wastes to protein for humans and animals. For example, certain yeasts have converted byproducts from papermills to a food protein.

There is a greater chance of adoption if waste is converted to animal feed rather than directly to edible products for humans. The major problem is that it would be easier to secure approval if these products are used in animal feeds. Even so, the probability of adoption by 1985 is low.

A very positive impact would come from providing additional food from waste products. The negative impacts would be the same as those for converting any waste to food: the possible health hazard presented and the problem of labeling so that consumers would know the source and yet not reject the food, Also conversion of petroleum substrates to protein by certain single-cell organisms has produced concentrations of nucleic acids, which can cause adverse reaction when fed to humans.

PACKAGING

Packaging materials may be developed in conjunction with and be an integral part of a new processing technology, or the attributes of a new package or material may lead to the development of new products. In some instances, packaging innovations may simply be a new way of packaging a traditional product.

Packaging represented 13 percent of the almost $123.5 billion marketing bill in 1977.[10] In order of use, food packaging is in the form of paperboard packages, followed by metal cans, flexible packaging, and foil containers.

[10]U. S. Department of Agriculture, Developments *in* Marketing Spreads for Food Outlook, ERS Report No. *398,* March 1978.

Changing lifestyles have contributed greatly to the increase in packaging and packaging costs (more working women, the increase in one- and two-person households, and the growth of special activities such as camping].

Modern packaging materials, innovative designs, and sophisticated packaging machines have played an important part in the success of the food marketing system. For instance, new packaging technologies such as the oxygen scavenger packaging material, " can reduce the need for food additives or preservatives. However, there is considerable criticism of the packaging cost component of food marketing (13 percent, second only to labor.' as a contributor to marketing costs). Changing conditions, such as increasing energy costs and the need for recycling of resources in limited supply, are expected to influence the types and extent of future food packaging. These developments could include commercial adoption of the retortable pouch and recyclable or returnable containers in food.

Retortable Pouch

The reportable pouch technology, while still being developed, has current applications and has received limited approval for use from the relevant regulatory agencies. Further adoption of this technology can be expected te have strong impacts and far-reaching consequences throughout the marketing system, particularly in the areas of energy, food storage, transportation, labor, and retailing. For this reason, the reportable pouch technology ranks as a top priority for assessment.

The pouch is a multilayer (plastic laminate with a middle layer of aluminum foil), adhesively bonded bag that will withstand thermoprocessing temperatures. It combines many advantages of the metal can and the plastic boil-in-the-bag. Use of retortable pouch materials produced by three firms have recently been approved by the FDA; and [JSDA, which has jurisdiction over the integrity of the pouch system, has approved retortable pouches made from these materials. The weight limit for the pouches approved for use is currently set at 16 ounces. When relevant test data are available, USDA will give consideration to removing the weight restriction or increasing its limit. The quality of food processed by this method is said to be superior to that of foods retorted in conventional cans, and taste tests indicate that it may approach that of frozen foods.

There have been problems in sealing the pouches, and the ability of the pouch to retain its integrity in commercial applications has not been tested in the United States. Thus, the reason for limited approval by USDA. Problems have also been encountered with slow filling times compared to cans. With growing use and application, however, technical innovations are expected to overcome such problems as these. The technology is still in its infancy, and many questions cannot be answered with hard data at this time.

An extension of retort pouch technology is the steam table "tray pack, " which uses a metal tray instead of a pouch and which uses the same container for processing, transporting, storing, and reheating the food. Food prepared in this way generally consists of a complete meal. The size and shape are designed to fit on an institutional steam table, and institutions are expected to be the first major market for the tray pack. The shape saves energy in processing and produces a superior product. In addition, serving food directly from the tray pack further reduces the need for labor and energy that would normally be used for cleaning steam table trays.

Data on energy savings in the manufacture of the retortable pouch over that used for metal cans, glass jars, and certain frozen food containers are preliminary and do not yet answer the question of energy consumption for each total system. While the reportable pouch appears to offer savings in energy over containers for frozen and canned products, these savings can only be confirmed by an analysis of the different systems that are or might be used commercially. Energy sav-

"This is a laminate consisting of a polyester outer layer, an adhesive layer, aluminum foil, a Surlyn® * sheet, a layer of palladium as a catalyst, and an inner layer of Surlyn®. Oxygen travels through the inner Surlyn " layer and reacts with hydrogen in the presence of the catalyst to form H_2O, which is trapped between the two Surlyn® layers. (* Surlyn®: registered trademark by E.I. du Pent de Nemours & Co.)

ings are possible in processing because the system uses a shorter cooking time at lower temperatures.

Savings may be projected in the area of transportation owing to the !mproved product-to-package weight ratio; savings in weight may be as much as 50 percent for the pouch versus the can. Although comparative tests have shown pouches to be as durable as cans, questions will continue to be raised regarding the handling of this package unti! experience has been obtained under actual use conditions. Initially, an outer package is being used to safeguard against breaks due to flexing and abrasion. Eventually, it may be possible to move the pouch through the marketing system without an individual cover for eacli pouch. Thought should also be given to the fact that, if not individually packaged in an outer carton, the reportable pouch would probably prove more difficult to price-mark and display in retail stores.

In its early stage of development, the reportable pouch technology will become a viable one for packaging food and will probably compete at first with frozen rather than canned food. If inroads into the $17 billion frozen-food market and ultimately into the $20 billion canned-food market are as significant as they are expected to be, there are substantial implications for these two industries. Producers of metal cans (and industries producing the raw materials) would be affected in terms of loss of revenue, displacement or relocation of labor, and possibly considerable loss of jobs.

The availability and prices of the petrochemicals needed to produce the plastics used for the pouch may also bear on the adoption and success of this technology.

Environmental impacts of this technology may be considerable in both a negative and a positive sense. If methods are not found that permit the pouches to be recycled, the impact would be negative compared to that of metal cans, bottles, and other recyclable containers (which result in savings in raw materials and energy). However, retortable pouches can be used as fuel, and even without recycling most of the energy initially expended in their manufacture could be reclaimed, at the same time minimizing solid waste problems.

Recyclable and Returnable Containers[12]

Technologies for recyclable containers. returnable cans and bottles, and other refillable containers have a high probability of being an important part of our future and that the impacts of adoption will be widespread. These technologies have developed because of socioeconomic pressure, and the pressure will in all events continue to build for new solutions through technology to the problems of conserving natural resources and reducing the expense of keeping our environment free from pollution caused by discard 'xl containers.

A discussion of these technologies falls into three categories: recyclable beverage containers, the returning of all food containers, and the general concept of recycling applied to all products.

Recycling of beverage containers Elas received the most attention to date. Four States have passed laws requiring deposits on all beverage containers, anti the major aluminum producers have initiated systems for buying back aluminum cans. Localities have set up collection points for cans, bottles, and other recyclable products. There have been mixed results in all these enterprises-for instance, reduced pollution and litter versus inconvenience of traveling to the collection site—yet the public seems intercsted in the concept of recycling even if the initial specific technologies or systems may not have met with their approval,

Returning containers to the processor for reuse is another concept relative to this technology. Reverting to a returnable packaging system is not a panacea for sanitary problems; indeed, some new problems may be created by this system. The beverage or food residue in returnable containers readily support the growth of insects and other undesirable vermin, or harmful microorganisrns, which contribute to unsanitary conditions in

[12]The OTA Materials Group has been studying some of the issues raised in this section, and is preparing a report on "Materials and Energy From Municipal Waste" which is expected to be published in the latter part of 1978,

a store selling food products. The issue of food safety and sanitation needs to be assessed.

Returnables may add to the cost of distribution and handling products. One study estimates it would cost 2 cents more per quart to deliver milk in returnable bottles. Whether the total cost of the delivered product would be greater for other products is not clear. If cost did increase, this would undoubtedly be passed onto the consumer. Part of this cost increase is because of the high initial cost for converting production lines in bottling plants to handle returnables. Estimates of this cost have run into billions of dollars. Larger companies would be better able to afford the expense of this conversion and thus could put the smaller firms at a competitive disadvantage. An assessment should evaluate policies for overcoming these kinds of capital problems resulting from the adoption of technologies.

If recycling becomes an important system, new forms of delivery may result to alleviate the inconvenience of, and dissatisfaction with, returnables and recyclable; for instance, a syrup or powder that could be mixed with carbonated water at home (both technologies are available).

Most soft drinks are vendor-delivered, and returnables would deter a consolidated delivery system, since by law empty bottles cannot be carried in the same truck with food products. This may provide the incentive to bottle beverages in larger units, which would run counter to the recent trend for smaller bottles and cans.

Recycling of all glass food containers has been proposed in the Oregon legislature for two legislative sessions. This is an extension of the recycling concept beyond beverage containers and may foretell a trend towards eventually recycling many food containers and packaging materials.

Several large projects for reclaiming and utilizing materials from garbage have been initiated. These are high-technology plants for separating recyclable metal, glass, and other materials and then burning the remainder to produce heat. There have been both successes and failures with these projects. An alternative would be to have consumers separate material before the refuse enters the recycling system. This is a system that has been in limited use since the early 1970's. There may not be one system applicable for every situation, but people may have to choose whether they wish to participate by paying for a centrally located or industry-based system with taxes or fees or whether they would prefer to lower the cost by participating directly.

Carton-Can

The carton-can is a square container with a flexible inner bag. The inner bag may be foil, plastic, or a combination. Advantages claimed are that its square shape saves space and material in shipping, it can be incinerated, and some versions are retortable. It is being used in Europe for processed foods but is still considered experimental. The probability of widespread adoption in the United States is considered very low, and impacts are difficult to judge primarily because of insufficient information on cost, where the carton-can is likely to be used, and whether food safety issues are involved.

This technology is important only insofar as it may be a part of an alternative packaging system that could affect materials and energy use and the transportation system.