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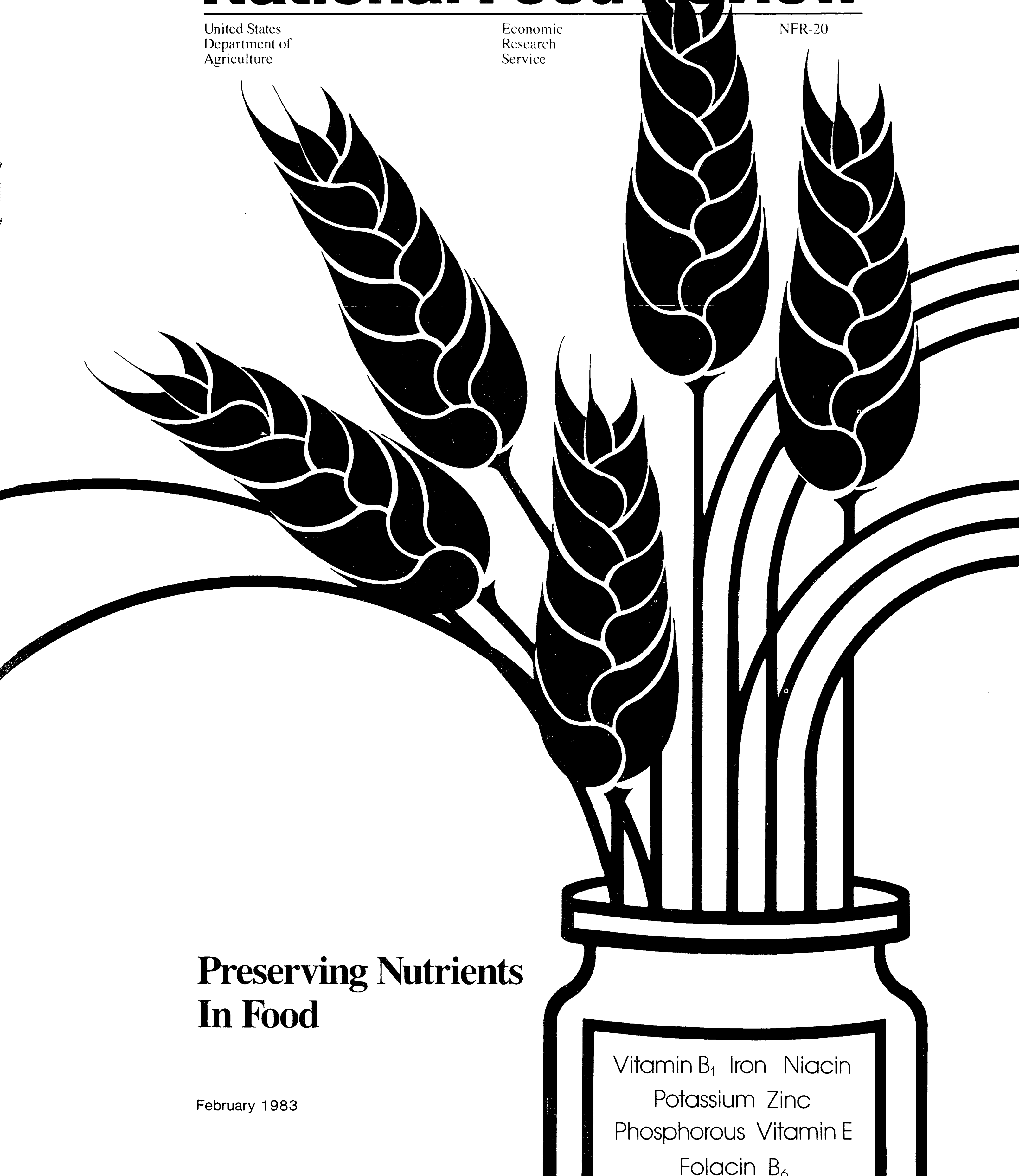

Preserving Nutrients In Food

February 1983

Preserving Nutrients In Food

Food preservation, necessary to feed the population of the world, has a drawback: nutrient destruction. To varying degrees, all nutrients in produce are jeopardized during storage, processing, and cooking. In fact, the moment produce is picked, its nutritional composition begins to change through oxidation. In processing, heat is one of the main culprits, but light, oxygen, water, and acid (pH) can also destroy nutrients.

What kind of fruits and vegetables—fresh, canned, or frozen—are the best nutritionally? Well, that depends on the nutrients you're looking for. ERS economist Tanya Roberts examines this subject in her article, "Food Preservation and Nutrition," which begins on page 2.

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Contents

February 1983

Food Preservation and Nutrition

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Indians living in the Peruvian Andes 3,000 years ago were the first known food preservationists, drying potatoes to eat in winter and spring. Food preservation techniques have come a long way since then, but the first "modern" breakthrough occurred in 1809 when Nicolas Appert developed a canning process that preserved foods for use by Napoleon's armies. And in 1880, freezing food for preservation, another of the most common methods used today, was discovered accidentally. A shipment of meat from Australia, usually refrigerated during passage, froze and arrived in England in better condition than the normally refrigerated meat.

Food preservation, however, has its drawback: nutrient destruction. To varying degrees, all nutrients are jeopardized by storage, processing, and cooking. The moment produce is picked, its nutritional composition begins to change through oxidation. In processing, heat is one of the main culprits, but light, oxygen, water, and acid (pH) can also destroy nutrients. Enzymes and trace elements, such as copper and iron, are commonly contained in foods and can promote these effects.

Nutrients in fresh foods vary according to their genetic stock, growing conditions, time they're picked, and other factors (see box). Processing, with its different impacts, adds a further question mark to nutrient content.

Currently, six basic methods of food processing and preservation are used:

- Moisture removal—drying, dehydration, concentration;
- Acidity control—fermentation and acid additives;
- Chemical processing—salt, sugar, nitrite, and other additivies;
- Heat treatment—blanching, pasteurization, sterilization, ultra-high temperature processing;
- Low temperature treatment—refrigeration, freezing; and
- Irradiation—exposing foods to gamma rays and x-rays that kill spoilage-causing microorganisms.

In 1910, 87 percent of the fruits sold were fresh, 3 percent were canned, and 10 percent were dried (figure 1). Similarly, in 1919, 85 percent of all vegetables were sold fresh, 13 percent were canned, and 2 percent were sold dried (figure 2). Home gardens were a significant source of vegetables in 1919, equaling half the commercial volume.

Americans, per person, now eat an average of 332 pounds of store-bought vegetables annually compared with 301 pounds in 1920. However, the form of vegetables has changed—frozen potatoes are substituted for fresh potatoes and canned vegetables have increased from 13 percent to 30 percent of commercial sales. There are some things that don't change. Fresh, store-bought vegetables, other than potatoes, account for about 100 pounds of the foods Americans eat every year—the same as in 1919. Dried bean consumption has also remained steady at around 6 pounds. In 1980, almost half our commercial vegetables were sold fresh, 30 percent canned, almost 20 percent frozen, and 2 percent of our commercial vegetables were sold dried.

Americans ate an average of 226 pounds of store-bought fruits per person in 1980, up one third since 1900. Today Americans consume 40 percent of their fruits fresh, 29 percent frozen (primarily as juice), 27 percent canned, and 4 percent dried. Consumption of fruits in juice form (frozen and canned) has increased so much that it is now slightly greater than fresh fruit consumption.

In terms of cost, drying by using natural sunshine remains the cheapest preservation technique for most foods. Smoke curing, fermentation, or adding salt, sugar, or acid can also be very inexpensive. Temperature-based processes such as canning or freezing are relatively costly, as are high technology processes such as irradiation. However, costs for canning and freezing are comparable (table 1). Previously, canning was cheaper, but increases in the price of tin have raised costs. At the same time, improvements in technology have lowered freezing costs.

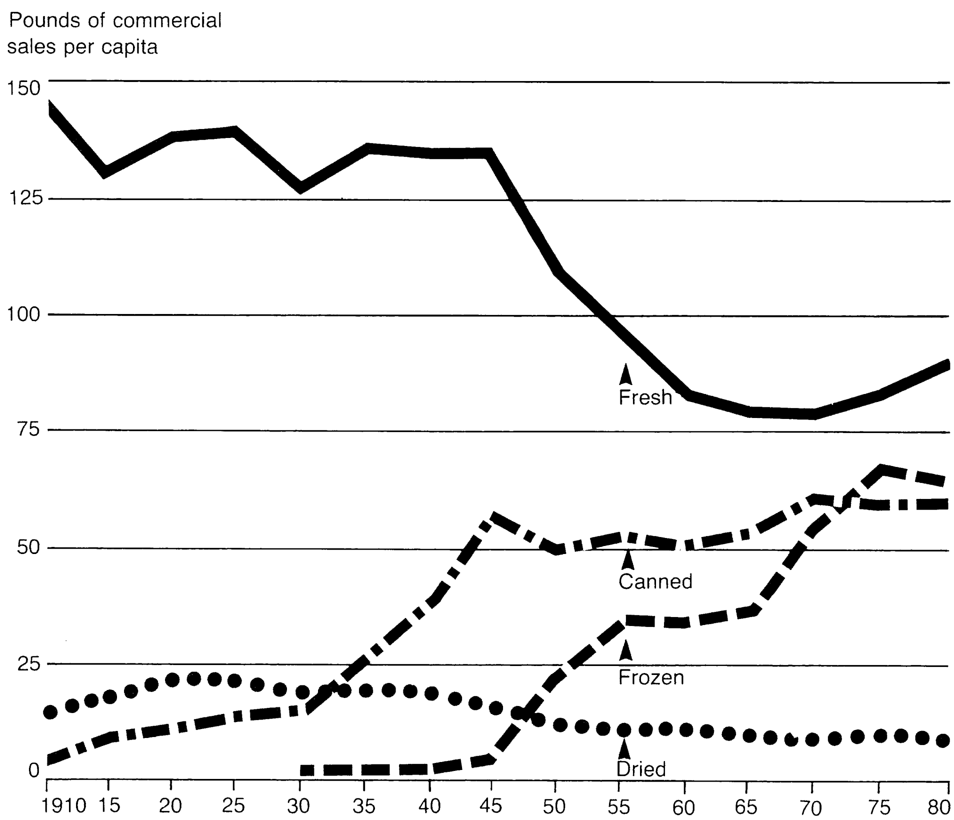
Both canning and freezing use similar amounts of energy. The higher energy use during freezer storage is generally offset by the lower energy use in manufacturing the freezer package versus the tin can. The multitude of processing equipment manufacturers, production line peculiarities, and the different preparation requirements for different foods cause energy estimates to vary. For example, one study cited the total energy requirement for producing a package of frozen corn at 13 percent higher than for producing canned corn. Another study reported 25 percent more energy required for producing canned peas than for processing frozen peas.

Table 1. Cost of Producing and Distributing 100 Pounds of Peas

Item	Canned	Frozen	Freeze-dried
Raw materials (all costs)	$ 6.39	$ 6.64	$ 6.64
Factory costs (labor, supervision, overhead)	3.37	3.06	7.72
Containers	5.87	2.51	4.19
Shipping	2.82	2.02	.60
Storage, 6 months	1.04	1.32	.70
Total cost	19.49	15.55	19.85

Source: James M. Flink, *Food Technology*, 1977.

Figure 1. Trends in Per Capita Fruit Purchases by Preservation Technique, 1910-1981 (Fresh Weight Equivalent)



Source: USDA

Food Preservation Processes

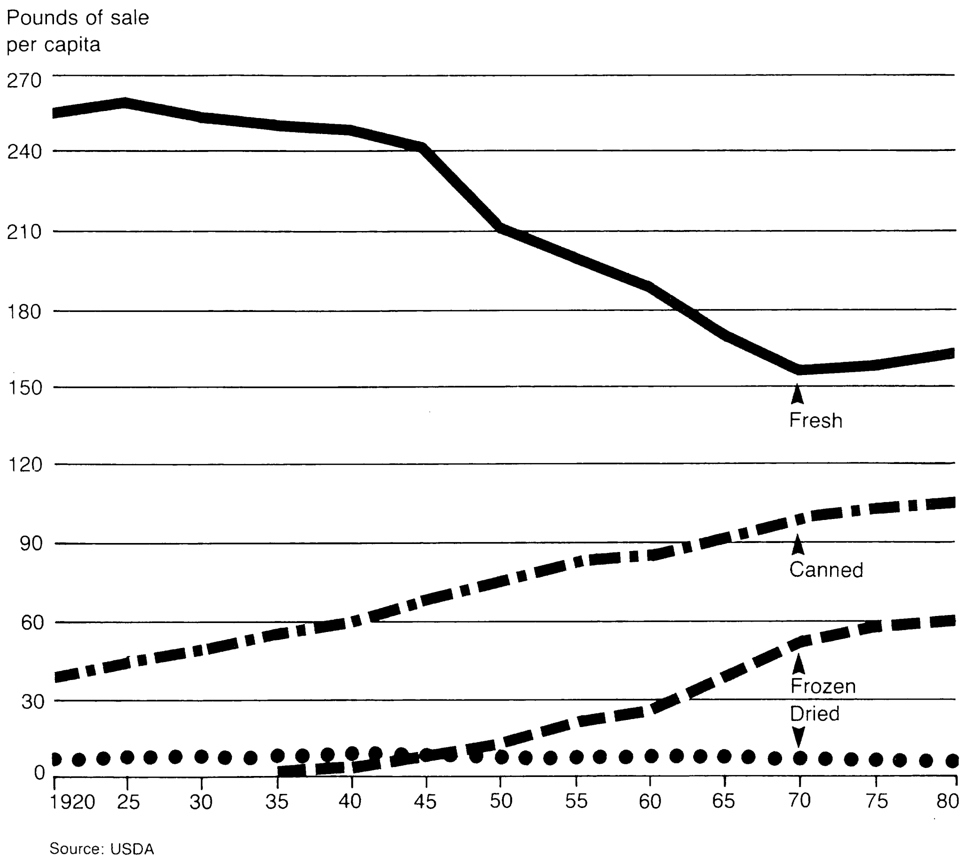
Dehydration. Drying improves the storage life of foods by depriving microorganisms of sufficient water to grow and reducing the rate of enzyme activity and chemical reactions. The Food and Container Institute, under contract to the U.S. Armed Forces, experimented with hot air drying, vacuum drying, spray drying, and freeze drying to compare their effects on the protein and vitamin values of food. Insignificant amounts of protein were lost during all four types of drying for meats, eggs, legumes, leafy vegetables, and sweet corn.

Vitamin retention was good, except for ascorbic acid (vitamin C) and beta-carotene. Only 5 percent of the other water-soluble vitamins (B-complex) were lost and none of the fat-soluble vitamins (A, D, E and K) were impaired.

To maintain their taste, appearance, smell, and nutritional quality, dried foods must be stored at low temperatures and low relative humidities. For example, Tressler reported virtually no loss of vitamin C in tomato flakes kept at 40 °F and 1 to 5 percent moisture during 32 weeks of storage. However, at 85 °F, these tomato flakes lost 30 percent of their vitamin C when the moisture was 1 percent, and lost over 80 percent of their vitamin C when the moisture was 5 percent.

Acidity control. Fermenting food to preserve it, improve the flavor, enhance nutritive value, or prepare exhilarating beverages has been practiced by nearly every civilization. Enzymes produced by yeast or bacteria are the catalysts in fermentation and convert carbohydrates to another product. Storing the fermented product in an air-tight container prevents most bacteria from growing. Yeast and mold fermentation often increased the B vitamins. For example,

Figure 2. Trends in Per Capita Vegetable Sales by Preservation Technique, 1919-1980 (Fresh Weight Equivalent)



Source: USDA

tempeh, Indonesian fermented soybeans, may have a doubling of its riboflavin content, and the niacin and B_{12} contents may be increases many fold. Another advantage of fermentation is that the cooking time is cut by two-thirds for tempeh when compared with raw soybeans.

Yogurt and buttermilk have a nutritional value comparable to the milk they are produced from. Cheese, however, loses vitamin C, niacin, riboflavin, thiamin (B_1), and water-soluble proteins when the whey is removed. The amount of vitamin A stays the same and some B-complex vitamins increased. However, these B vitamins are on the crust and rind and are not generally eaten.

Heavily salted fermented products, such as pickles and olives, leach most of their water-soluble vitamins into the brine during curing. Fermented sauerkraut and other vegetables in a low-salt brine retain most of their nutritive value both because there is less leaching of nutrients and because the liquid containing the leached nutrients is often consumed with the vegetable.

Additives. Heavy salting of food is an inexpensive way of stopping bacterial growth. And salting was the primary preserving technique for meat, fish, and poultry before the invention of canning and freezing. Heavy salting alters fish proteins but may not reduce their nutritional availability to humans, although it is possible that proteins may be leached out. The effect on vitamins and minerals is not known. Light salting, primarily used in the United States now for flavor enhancement, does not cause appreciable nutrient loss.

High-sugar processing also pulls the water out of bacterial cells, causing them to die. Generally, the products treated—jams, candied fruit—are not an important part of the meal and their nutritional value is insignificant.

Nitrite, sulfites, and other chemical additives present a varied picture, depending on the food, its pH (acidity), and the specific nutrient. For example, sulfite destroys thiamin in meats but protects vitamin C and beta-carotene in dried fruits. Nitrite causes bacon to lose 30 percent of its vitamin C after processing and an additional 30 percent when fried after 6 months of storage.

Irradiation. While not generally approved for food use in the United States, the loss of nutrients during irradiation appears to be less than for canning. Food irradiation increases the shelf life of fresh fish and poultry products, delays the softening of mature fruits, inhibits sprouting in potatoes, and disinfects wheat and wheat products. (See the article "Food Irradiation Hinges on Approval, Feasibiity, and Acceptance" in this issue.)

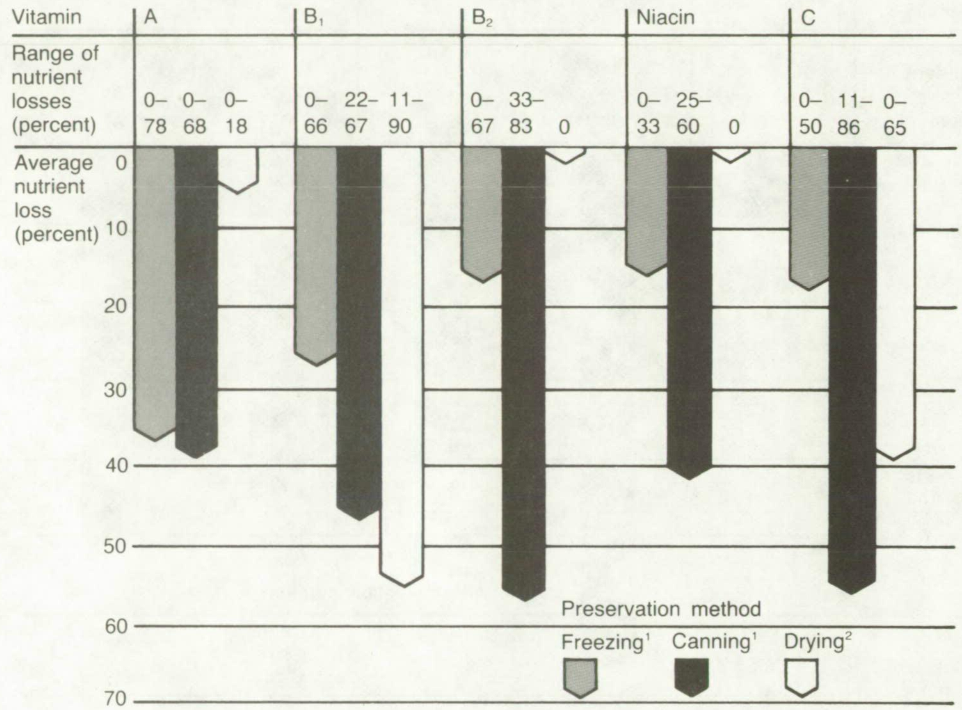
Canning and Freezing. Any heat treatment reduces the nutrient value of foods. Generally, the greater the time and temperature, the greater the loss. Traditional canning is the most destructive since the food near the exterior of the container is subjected to severe heat stress before the food in the center reaches a temperature sufficient to destroy pathogens. The amount of nutrient loss depends on the food, the machinery, canning process, and the numerous other variables. (For a discussion of comparative nutrient loss in canned, raw, pasteurized, and ultra-high temperature processed (UHT) milk, see NFR-18, Spring 1982.)

Freezing is generally regarded as the best method of long-term food preservation in terms of retaining sensory attributes and nutrients, but it causes water soluble vitamins to be lost, especially if water blanching is used instead of steam blanching. Further nutrient loss occurs during prolonged storage or when the storage temperature is not kept low enough.

Researchers have used two methods to compare nutrient retention by type of processing. One method subjects a bushel of fresh produce to different preservation processes and evaluates the remaining nutrients. The other method analyzes the canned, frozen, dried, and fresh products sampled from the marketplace. However, different genetic stocks can be used for different processes. For example, clingstone peaches are the predominant peach used in canning, whereas freestone peaches are sold for fresh consumption.

USDA uses the second approach, referred to "as purchased," in Agriculture Handbook No. 8, "Composition of Foods: Raw, Processed, Prepared." Owen Fennema of the University of Wisconsin has analyzed this data and calculated losses of vitamins in groups of fruits and vegetables. The five vitamins chosen, A, B_1, B_2, C, and niacin, are the most likely to be lost in processing. For example, vitamin C and thiamin (B_1) are water soluble, which means they cannot be stored in the body, they are subject to leaching during processing, and are highly susceptible to chemical degradation.

Figure 3. Vitamin Losses in Fruits During Freezing, Canning, and Drying



[1]Fruits analyzed were apples, apricots, blueberries, pie cherries, orange juice, peaches, raspberries and strawberries.
[2]Fruits analyzed were apples, apricots, orange juice and peaches.

Nutrient Variability in Raw Foods

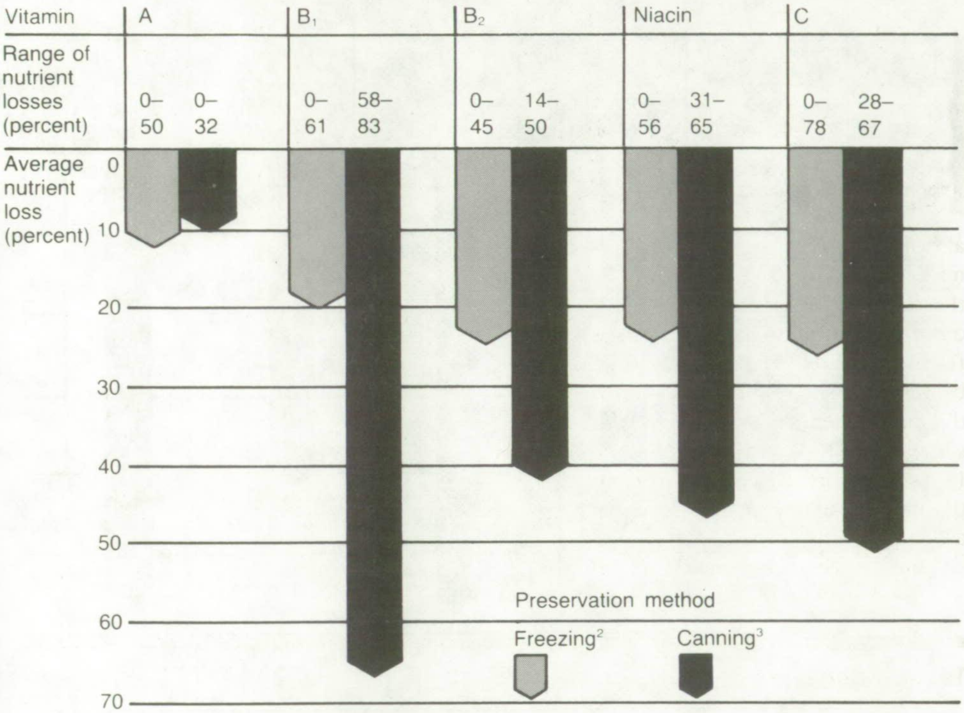
The nutritional value of raw foods varies considerably from one batch to another, due to location, weather, agricultural practices, soil composition, and genetic stock. For example, Atlantic oysters are more nutritious than Pacific oysters. On a per calorie basis, Atlantic oysters contain 10 percent more protein, 54 percent more calcium, 28 percent more phosphorous, 5 percent more iron, and 171 percent more niacin. California avocados contain 15 percent more fat than those grown in Florida, while California navel oranges contain 34 percent more vitamin C than Florida oranges.

The age of the vegetable or grain also affects the nutrient content. As carrots mature, their vitamin A content increases appreciably. Ripe red tomatoes have 3.6 times as much vitamin A as green tomatoes, and mature red sweet peppers have 7.5 times as much vitamin A as immature green peppers. However, mature alfalfa has half the protein as alfalfa harvested earlier at the pre-bud stage.

The season of the year has an effect on the riboflavin (B_{12}) content of wheat, corn, and milk. But seasons do not affect the riboflavin content in snap beans or lima beans.

Genetic engineering has enabled the development of "super-sweet" corn as well as corn high in lysine (the amino acid in shortest supply in a corn-based diet). Plant breeding has decreased the fat in hogs and doubled the total milk production of dairy cows.

Figure 4. Vitamin Losses in Frozen and Canned Vegetables Compared to Fresh-cooked[1] Products



[1]Boiled and drained.

[2]Frozen, boiled and drained. The vegetables analyzed were asparagus, lima beans, green beans, broccoli, brussel sprouts, cauliflower, corn, peas, potatoes and spinach.

[3]Canned, drained and heated. Same vegetables except broccoli, brussel sprouts and cauliflower excluded.

The average nutrient loss for eight fruits when frozen is about one-third of vitamins A and B_1, and about one-fifth of the niacin, B_2, and C, compared with the loss of these vitamins from fresh fruits (figure 3). Canning losses are greater and range from 40 to 60 percent when compared with losses from fresh fruits. Dried fruits show almost no loss of A_1, B_2, and niacin; however, roughly half the vitamins C and B_1 are destroyed in apples, apricots, orange juice, and peaches.

The comparison of vegetables on an "as purchased" basis when heated for dinner table consumption revealed the following:

- Ten common vegetables contain about 10 percent less vitamin A, and about 25 percent less niacin and vitamins B_1, B_2, and C when frozen and cooked than when cooked without being frozen first (figure 4);
- Seven canned vegetables lost 10 percent of vitamin A; over 40 percent of vitamins B_2, niacin, and C; and two-thirds of vitamin B_1, when compared with vegetables that were cooked without being canned first.

Research using the first technique, the "bushel basket" approach, is in progress by the National Food Processors Association. Preliminary results have pointed to even smaller differences among processing techniques.

The scientific data base is being continuously refined and updated to reflect:

- New analytical techniques for detecting nutrients and determining their bioavailability;
- New genetic stocks of foods which are more disease resistant, less perishable, or more compatible with mechanical harvesting, and which have nutrient profiles different from the older species;
- Changing techniques for handling produce both before and after processing;
- Changing industry production practices such as ultra-high temperature or retort packaging, lye peeling of fruits and vegetables, and steam blanching instead of water blanching;
- Adoption of different food fortification practices by industry;
- Changing home cooking practices such as cooking vegetables with less water and for shorter time periods, or microwave oven use. ■

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Food Irradiation Hinges on Approval, Feasibility, and Acceptance

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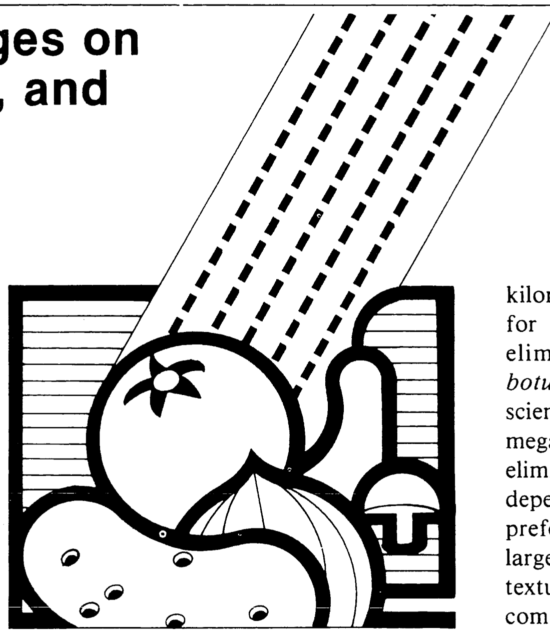


Irradiation may soon join the conventional processes of canning, freezing, and curing for preserving food in the United States. It is currently being considered for approval by the Food and Drug Administration (FDA) after more than four decades of research. FDA's approval could signal a technological revolution in commercial food processing. However, even if it is approved, irradiated food still faces challenges in the marketplace: consumer acceptance, economic feasibility, and market development by food processors.

Irradiation preserves food by killing the microorganisms that cause it to spoil by the use of gamma rays, x-rays, or electrons. Gamma rays are produced by a radioactive isotope, cobalt-60 (sometimes cesium-137); x-rays and electrons are produced by an electron beam generator powered by electricity. Electrons have less penetrating ability, but can be more economical for irradiating high volumes of small food particles such as grains. Both gamma and x-rays have energy levels that can penetrate bulky substances.

Besides food preservation, irradiation has a number of industrial uses, including treating the insulation on wire and cable, cross-linking plastic food wrap, vulcanizing sheet rubber, and sterilizing medical devices. In fact, hundreds of industrial plants in the United States use cobalt-60 or electron beam generators for some applications. The gamma plants are licensed and inspected for safety by the Nuclear Regulatory Commission. The electron facilities are controlled by various State agencies.

Effects of Irradiation

The dosage of irradiation applied to a product determines the preservation effect. A low dose of 5 to 100 kilorads (a rad is a measurement of absorbed dose) inhibits sprouting in root crops such as potatoes and onions and retards ripening of fruits. Low doses of irradiation can also sterilize or kill insects which infest and destroy grain or fresh fruits and vegetables.

Higher dose levels of 100 to 700 kilorads inhibit post harvest fungi development in perishable fruits, and reduce the number of microorganisms and spores which cause deterioration of flavor, texture, odor, and appearance. Elimination of these spoilage microorganisms can often double or triple the shelf life of some foods, such as fresh chicken, with only marginal changes in the flavor of the food. Longer shelf life could be particularly useful for red meat products, the most expensive item in the average consumer's food budget, which spoil quickly. In addition, irradiation can sharply reduce the number of microorganisms which pose a public health threat, such as salmonella.

Much higher dose levels, over 1,000 kilorads (or 1 megarad), can sterilize food for indefinite, unrefrigerated storage by eliminating pathogens including *C. botulnum.* The dose level suggested by scientists to completely sterilize foods is 4.5 megarads. But the actual dose necessary to eliminate pathogens may be less, and depends on the specific food. Technologists prefer to use the minimum dose because too large a dose can alter a food's flavor and texture. Mild heating, curing, or freezing in combination with irradiation can reduce the dose level necessary to extend the shelf life of food. Combination treatments eliminate the chemical sources of spoilage, such as enzymes, which irradiation alone cannot inactivate.

By extending the warehouse life of foods, irradiation can help stabilize market supply, and even open up new markets which were previously excluded by long distances from production sites. Cost savings could be realized from reduced spoilage losses. Some foods would no longer require refrigerated transportation and storage. Also, studies

Table 1. Some Foods That Can Be Irradiated

Food item	Purpose	Dose
White potatoes,[1] root crops	Sprout inhibition	5-15 kilorads
Wheat, wheat flour,[1] grains	Disinfestation	20-100 kilorads
Fresh fruits and vegetables	Disinfestation, extension of shelf life	25-100 kilorads
Mushrooms	Inhibit cap opening, fresh appearance	6-100 kilorads
Tropical fruits	Retard ripening	25-100 kilorads
Strawberries, small fruits	Controlling fungus	175-225 kilorads
Cod, ocean perch	Extension of shelf life	175-225 kilorads
Crab	Extension of shelf life	200-300 kilorads
Chicken	Extension of shelf life, reduction of pathogens	300-700 kilorads
Portion controlled ham (refrigerated storage)	Extension of shelf life, reduction of pathogens	200-700 kilorads
Prime beef cuts (refrigerated storage)	Double shelf life	200-700 kilorads
Frozen shrimp, frog legs (Imported)	Eradicate salmonella	500 kilorads
Spices	Sterilization	1,000 kilorads
Meats, poultry, and fish	Sterilization	2,500-5,000 kilorads

[1]Permitted with labeling in the United States since 1963.

show that irradiation actually uses less energy than other food processing techniques (see table 2).

Another important benefit of irradiation is that it can be used as an alternative to chemical preservatives such as nitrite and chemical fumigants such as ethylene dibromide. Ethylene dibromide is carcinogenic, and the Environmental Protection Agency and FDA are searching for alternative methods to disinfest fruits and vegetables, spices, and grain.

Table 2. Typical Energy Values Used for Processing of Chicken

Process	Energy used
	kJ/kg
Irradiation with 250 kilorads	21
Irradiation with 300 kilorads	157
Heat sterilization	918
Blast freezing from 4.4°C to −23.3°C	7552
Storing the product at −25°C for 3.5 weeks	5149
Refrigerated storage for 5.5 days at 0°C	318
Refrigerated storage for 10.5 days at 0°C	396
Cooking the whole thawed chicken at 93°C	2558

Source: Ari Brynjolfsson. "Energy and Food Irradiation." *Food Preservation by Irradiation. International Symposium.* Vol. II. International Atomic Energy Agency. Vienna 1978. p. 286.

FDA Approval

Before food irradiation can be used commercially, it must be approved by the FDA. FDA approval is a complicated process. Since irradiation is listed as a food additive in the 1958 Food Additives Amendment of the Federal Food, Drug and Cosmetic Act, processors must use scientific tests to prove that irradiation is safe for each food item they plan to irradiate.

Ionizing radiation creates traces of radiolytic compounds which are not normally found in the food before irradiation. Scientists have found that other processes, such as cooking, also create some of the same compounds. In spite of the term "radiolytic," which means "produced from radiation," these unique radiolytic products (URPs) are not radioactive. Vacuum packaging or bringing the food to a sub-zero temperature during irradiation sterilization drastically reduces the formation of radiolytic products, thus improving the flavor, color, and texture of irradiation-sterilized foods.

Current concern over the safety of irradiated foods centers around URPs. So far, no URPs have been found to be toxic in the trace amounts found in irradiated food. However, the FDA still needs more data on URPs in order to establish their safety.

Eugene Wierbicki of USDA's Eastern Regional Research Center (ERRC) in Philadelphia has been working on the problem of URPs in irradiation-sterilized meat products for years. In 1980, the ERRC took over research which the Department of the Army has been conducting since 1953. The work on sterilized chicken is almost completed. If analysis of the data shows that irradiation-sterilized chicken is safe for humans to eat, then USDA will submit a petition to the FDA. The ERRC is also conducting research on irradiation as an alternative to nitrite in bacon, and initiating new research on low dose irradiation of other foods.

Testing irradiated foods for safety is lengthy and expensive. The uncertainty of FDA acceptance of test results has prevented many food processors from pursuing irradiation research. For this reason the FDA has decided to reconsider its position on irradiated foods.

Table 3. Rate Of Return For Cobalt-60 Irradiation Of Selected Commodities Predicted For 1976-85

Crop	Low volume: Predicted average annual volume	Low volume: Annual return on capital	High volume: Predicted average annual volume	High volume: Annual return on capital
	Million pounds	Percent	Million pounds	Percent
Strawberries	12.0	Negative	70.5	46
Mushrooms	21.2	119	35.3	209
Papayas and mangoes	20.6	48	40.0	70
East coast finfish	5.7	Negative	27.4	30
Shrimp	8.8	Negative	79.0	239
Blue Crab	12.3	132	na	na

na = not available

Source: *Cost Benefit Analysis of Selected Radiation Pastuerized Foods.* United States Atomic Energy Commission. Technical Information Center. September 1972.

The FDA published an Advanced Notice of Proposed Rulemaking (ANPR) in the March 27, 1981, *Federal Register* which included the following suggestions:

- Permit food irradiation at dose levels up to 100 kilorads for disinfestation of grains, fruits, and vegetables, without animal feeding studies. Manufacturers could use this level after proving to FDA through a registration process or a limited approval system that their process is effective.
- Publish clearer testing protocols to help manufacturers demonstrate to FDA the safety of foods irradiated with doses above 100 kilorads.

• Classify as safe, with minimum testing, food irradiated at doses up to 5 megarads, if the food normally constitutes less than 0.01 percent of the daily diet.

One set of opposing comments received by the FDA was from the Community Nutrition Institute (CNI), a nonprofit public interest organization in Washington, D.C. CNI contends that the use of radiation technology on food may pose a threat to the local environment near a radiation facility. CNI also suggests that particular groups of people, especially consumers who center their diets around fresh fruits and vegetables, might eat more irradiated food than the FDA estimate of 10 percent. The impact of any possible toxic substances could be greater at higher levels of consumption. Furthermore, CNI expressed doubt in the FDA's ability to monitor irradiation processing once it is approved, given the food industry's inexperience with the new technology.

Radiation technologists, however, stress the safety of irradiated foods. They explain that irradiation does not make foods radioactive, and does not release radioactivity to the environment. The FDA is considering all comments, along with additional scientific data, in writing a proposal. This proposal will be followed by another comment period. The final ruling is expected some time in 1983. The specific content of the ruling cannot be predicted yet.

Economic Feasibility

If food irradiation surmounts the hurdles of safety evaluation and FDA approval, it still faces the challenge of economic feasibility. Irradiation is limited to specific food items at particular doses. Each food item must be tested individually to find the appropriate dose or combination of processes that will sterilize, pasteurize, or disinfest the product without destroying its flavor, texture, or nutritional value. The economic benefits of irradiation depend on variables such as the volume of food processed through each radiation facility.

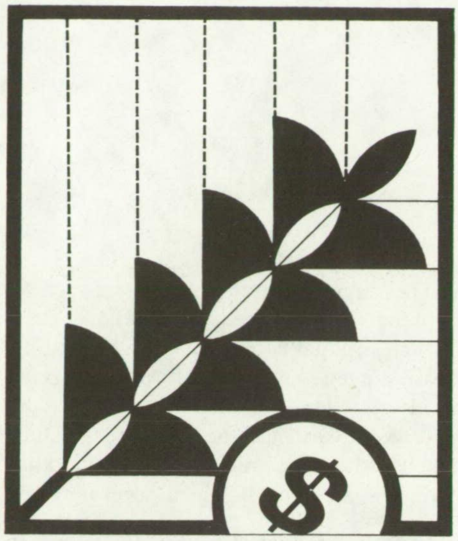
A cost-benefit analysis of irradiation was conducted in 1972 by the U.S. Atomic Energy Commission, the Economic Research Service of USDA, the Bureau of Commercial Fisheries of the U.S. Department of the Interior, and a private contractor. An initial list of 61 commodities was narrowed down to six which showed the best potential for commercial-scale irradiation from an industry investment point of view.

The six commodities—strawberries, mushrooms, papayas and mangoes, east coast finfish, shrimp, and blue crab—were selected because they are highly perishable, high-value items with production concentrated in a few major areas. The analysis compared, over a 10-year period, the estimated rate of return on the money invested in an irradiation facility. The rate of return was computed by balancing the cost of building and operating a cobalt-60 irradiation facility against the predicted increased revenue from reductions in spoilage losses and retail markdowns, and lower transportation costs.

Table 3 shows that a high rate of return on investment depends largely on a high volume of product moving through the irradiation facility. The importance of economies of large scale production, combined with the requirement for a large outlay of capital ($2 million to $4 million) to build an irradiation facility, could have a significant impact on the structure of the food industry.

Small producers would not be able to efficiently irradiate their yields. They would have to combine their output with those of other small producers or find different outlets for their crops. If irradiated commodities become very popular, the few large firms or cooperatives producing those items could command premium prices. The presence of middleman firms producing irradiated commodities could alter the way some of them are marketed.

In the past 10 years, the six industries with favorable potential have had varied interest in irradiation research. David Riggs, executive director of the California Strawberry Advisory Board, explains that the strawberry industry now has only limited interest in irradiation. Riggs explains that strawberries currently receive little postharvest treatment, except for a tiny quantity that is shipped to Japan. Improved transportation practices and alternative technologies may have made irradiation of strawberries unnecessary.



Irradiation of Wheat: Approval Does Not Mean Acceptance

Robert Malnati, Director of Marketing at High Voltage Engineering Corporation in Burlington, Mass., estimates the operating costs for disinfesting wheat with a 50 kilorad dose of irradiation to be 1.5 cents per bushel of wheat. This operating cost includes amortization, interest, labor, utilities, and maintenance. The total cost of the single story, 2,500-square-foot electron beam process station, including electron beam equipment, grain handling equipment, biological shield, instrumentation, controls, and the building itself, is estimated to be $2 million. The electron process station is assumed to operate 4,000 hours per year, irradiating 211,200 bushels of wheat per day, year round.

Low-dose irradiation to disinfest wheat and wheat flour and to inhibit sprouting of potatoes has been legal in the United States since 1963, but it has never been used. Wheat industry experts explain that irradiation of wheat is not economically feasible in the United States. The dry climate and proper storage in clean, dry silos prevent significant losses from insect infestation. The capital outlay for an irradiator and the volume of wheat necessary would be too high to make irradiation economical for small farmers. However, in countries with humid climates and inadequate storage facilities, low-dose irradiation may be a promising alternative to losses, currently estimated at up to 30 percent of stored grain.

Changes in industry characteristics of the other commodities have increased their potential for economic benefits from irradiation. In addition, the industry is trying to increase sales to supermarkets with a program of guaranteed quality. Irradiation of finfish could provide that guarantee. John Kaylor of the Gloucester Laboratory of the National Marine Fisheries Service in Massachusetts says that the East coast finfish industry is waiting only for FDA's final ruling. Radiation Technology, Inc. of Rockaway, N.J., is building a facility in Rhode Island which can irradiate a variety of finfish and shellfish. The company is planning to export the irradiated seafood until it is approved for sale in the United States.

Market Potential

Not all food irradiation enthusiasts are in agreement about the market which irradiated foods are best suited. Some experts see potential in the export market. Many people see irradiated food as one way to alleviate world hunger. Losses due to spoilage have been estimated at 25 to 30 percent of the world's food harvest.

Irradiated food may be sought after by consumers who want shelf stable foods without chemical preservatives. Elliot DeGraff of Neutron Products Corporation, Inc., suggests that the U.S. market for irradiated foods may be for specialty items, such as dietetic food, or food used on camping trips. DeGraff predicts that irradiated food will be a "premium product which may command a premium price."

One important reason food processing firms may be hesitant to endorse food irradiation technology is their uncertainty about the reaction of consumers. Food processing firms will avoid irradiation as long as there is the danger of cost savings being offset by a loss of revenue from declining sales.

One problem is labeling, and the FDA is struggling with debate on this subject. Specifically, many food technologists argue that labeling foods as irradiated is inappropriate because irradiation is a process not an additive.

They argue that other processes, such as cooking, do not require labeling, even though residual compounds are formed by those processes as well. (However, current food safety laws list irradiation as an additive. Additives must be listed on product labels.) Another possibility is to find another term for the process which accurately describes it without suggesting radioactivity. Alternative terms which have been suggested are "cosmic processing," "picowave processing," or "processed with ionizing energy."

Many consumer advocates have commented that if food is going to be irradiated consumers should know about it. Many experts contend that if labeling is required, a careful program of consumer education is essential for consumer acceptance. Once consumers regard the product and the process as safe, they will be more willing to recognize its benefits.

Offering cost savings, as well as public health benefits, food irradiation may be the food processing technology of the future. The eventual implementation of food irradiation technology depends on the new regulatory requirements, public acceptance of irradiated foods, and the cost of these foods in comparison to conventionally preserved foods. ■

International Interest

International interest in food irradiation has continued to gain momentum, especially in developing countries where limited transportation and storage networks make spoilage a serious problem. Food irradiation holds the promise of retarding food spoilage during storage and transportation.

In 1956, the Food and Agriculture Organization (FAO) of the United Nations held the first international meeting to review the feasibility of food irradiation. The FAO held another meeting in 1958 on the uses of ionizing radiations for food preservation. Throughout the 1960's, international organizations continued to study the feasibility, wholesomeness, and legal aspects of food irradiation. Since 1970, research has been coordinated by the International Project in the Field of Food Irradiation, part of the Organization for Economic Cooperation and Development.

In 1976, the FAO, the International Atomic Energy Agency, and the World Health Organization appointed the Joint Expert Committee on Food Irradiation (JECFI) to study the scientific, legal, and economic aspects of food irradiation. In 1980, the JECFI recommended that food irradiated at dose levels up to 1 megarad be approved for international use. The Codex Alimentarius Commission, an international body which develops international standards for food, is in the process of adopting JECFI recommendations.

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Per Capita Food Consumption Highlights for 1981

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Per capita food consumption fell 7 pounds last year to 1,400 pounds, as Americans ate, on the average, less of both animal and crop products. Animal product usage dropped 5 pounds to 582 pounds in 1981, and crop product consumption declined 2 pounds to 818 pounds. Declines in pork, eggs, and whole milk were primarily responsible for the lower animal product consumption, while declining vegetable and potato consumption was greater than increases in other crop products.

Meat, Poultry, and Eggs

Total red meat consumption fell 2.5 pounds per person in 1981 to 145.2 pounds. A year earlier it had increased 2.8 pounds. The decline stemmed from a sharp 3.3-pound drop in 1981 per capita pork usage, which more than offset a 0.7-pound increase in beef consumption.

The drop in pork consumption reflected a 4.5-percent decline in 1981 production. Hog producers experienced financial losses in 1979 and 1980, and reduced their breeding inventories in 1980. This led to the 1981 production decline which forced farm prices for hogs and retail pork prices up. The 1981 Consumer Price Index (CPI) for pork rose 9.3 percent.

The per capita beef consumption increase in 1981 was the first rise since 1976—the peak of the last cattle cycle's liquidation phase—when production and consumption of beef reached historical highs of nearly 26 billion pounds nationally and 94.4 pounds per person. Production declined in

Table 1. Per Capita Consumption, Selected Items,[1] Selected Years, 1960-81

Food item	1960	1970	1979	1980	1981[2]
			Pounds		
All items	1400.1	1397.0	1415.1	1406.9	1399.8
Animal products	614.2	614.2	589.9	587.4	582.2
Crop products	785.9	782.8	825.2	819.5	817.6
Total red meat (excluding game and offal)	134.0	151.6	144.9	147.7	145.2
Beef	64.2	84.0	78.0	76.5	77.2
Pork	60.3	62.3	63.8	68.3	65.0
Lamb and mutton	4.3	2.9	1.3	1.4	1.4
Veal	5.2	2.4	1.7	1.5	1.6
Fishery products	10.3	11.8	13.0	12.8	13.0
Chicken	27.8	40.4	50.6	50.1	51.7
Turkey	6.2	8.0	9.9	10.5	10.7
Eggs	42.6	39.1	35.2	34.6	33.6
All dairy products	653.4	560.7	547.7	544.3	541.5
Fluid whole milk	263.9	213.3	150.1	143.5	137.9
Total cheese	8.3	11.5	17.2	17.6	18.2
Butter	7.5	5.3	4.5	4.5	4.3
Ice cream	18.3	17.6	17.1	17.3	17.2
Fats and oils—total fat food content (including butter)	45.1	52.6	55.8	55.8	56.9
Animal fats	18.1	14.1	11.0	11.0	10.8
Vegetable oils	27.0	38.5	44.8	44.8	46.1
Total fruit	139.4	134.5	136.2	141.2	142.3
Processed	50.3	55.6	55.5	55.4	55.0
Fresh	89.1	78.9	80.8	85.7	87.3
Total vegetables	146.6	152.1	160.8	159.2	154.3
Fresh (commercial)	96.2	91.4	96.4	99.0	97.1
Processed	50.4	60.7	64.4	60.2	57.2
Wheat flour	118.2	110.8	117.2	116.9	116.6
Rice	6.1	6.7	9.4	9.4	11.0
Sugar	97.6	101.7	89.3	83.7	79.4
Corn sweeteners	10.2	18.4	43.3	48.9	55.0
Coffee	11.6	10.4	8.5	7.8	7.7
Soft drinks (gallons)	13.6	23.7	36.8	37.8	38.0
Spirits	1.9	2.5	2.6	2.5	2.5
Beer	22.0	25.2	30.5	30.9	31.1
Wine	1.3	1.7	2.5	2.8	2.7

[1] Alcoholic beverages are in gallons of beverage volume for the drinking age population.
[2] Preliminary.

1977-79, but rose in 1980 and 1981 as earlier decisions to hold back heifers for breeding resulted in more available cattle for slaughter in 1981. The increased beef supply, along with plentiful poultry supplies and slow economic growth, helped to moderate retail beef prices, which were up only 0.8 percent in 1981.

Poultry production reached record levels in 1981 and consumption rose 3 percent to 62.8 pounds. Americans ate, on the average, 51.7 pounds of chicken and 10.7 pounds of turkey. Reduced supplies of red meats and sluggish growth in income stimulated the poultry consumption rate.

Egg consumption fell 3 percent from 1980's level to 265 eggs per person, an all-time low. This was caused by a reduction in 1981 domestic supplies because of higher feed costs, and a 54-percent rise in exports. The 1981 consumption decline for eggs continued a 30-year trend—down 32 percent since 1950 due to Americans' changing lifestyles and breakfast habits.

Dairy

Per capita consumption of all dairy products on a milk-equivalent basis decreased slightly to 542 pounds in 1981. Total milk production rose 3.2 percent in 1981 as the number of milk cows increased by 1 percent and milk output per cow increased about 2 percent. Milk used for fluid items, such as whole milk, cream, and yogurt, declined about 1 percent to 50.2 billion pounds in 1981, while milk used in manufactured dairy products increased 6.1 percent to 77.8 billion pounds, a record level.

The increased use of milk for manufacturing in 1981 was reflected in record cheese production of 4.2 billion pounds, which helped increase per capita cheese consumption in 1981 to a record 18.2 pounds. Commercial disappearance of cheese increased 4.5 percent in 1981 to 4 billion pounds, and USDA donated 151 million pounds of cheese to needy persons.

The trend in cheese consumption has been one of increased use since 1960. Consumption of American-type cheese increased from 5.4 pounds per person in 1960 to 10.1 pounds in 1981. Per capita usage of Colby and Monterey Jack has increased about 158 percent since 1970. Consumption of other cheeses increased from 2.9 pounds to 8.1 pounds in this period. The explosive growth in this category stems from large gains in consumption of Swiss (up about 68 percent since 1960) and Italian types (up 350 percent).

Consumption of other manufactured dairy products was stable in 1981. Evaporated and condensed whole milk usage was up slightly to 4.1 pounds per person, while ice cream, butter, and nonfat dry milk consumption fell to 17.2, 4.3, and 2.7 pounds per person, respectively.

Americans consumed 246 pounds of fluid milk items per person in 1981, down from 250 pounds in 1980. Consumption of plain whole milk declined by 5.6 pounds to 137.9 pounds per person, reflecting continued competition from lowfat milks, soft drinks, and fruit juices. Per capita sales of most fluid milk items were weak with skim milk, flavored milk, buttermilk, and yogurt declining. Per capita lowfat milk sales, however, increased 3.3 percent in 1981 to 74 pounds.

Fats and Oils

Total fats and oils consumption (fat content basis) rose 1.1 pounds in 1981 to 56.9 pounds per capita, a record high. More salad and cooking oils and shortening were eaten, while consumption of margarine and butter was down in 1981.

Because of lower butter consumption, per capita consumption of animal fats fell from 11 pounds to 10.8 pounds. Vegetable oil consumption continued its upward trend in 1981 with per capita usage rising to 46.1 pounds, a historical high.

The major vegetable oil used in 1981 was soybean oil, which accounted for 80 percent of all oil used in the manufacture of salad and cooking oils. Soybean oil also accounted for 64 and 84 percent, respectively, of all fats and oils used in the production of shortening and margarine in 1981. Corn oil is the second most widely used oil in margarine production and salad and cooking oils. In recent years, coconut and palm oil have been more widely used in shortening manufacture.

Fruits

Per capita consumption of fresh fruits rose 1.6 pounds to 87.3 pounds. Noncitrus fruit consumption increased to 62.7 pounds per person, its highest level since 1953. Per capita apple and banana usage reached 20-year highs at 20 and 21.5 pounds, respectively. The increase in noncitrus fruit consumption is attributed to consumer health concerns, more promotional activity, and the reduced supply of citrus fruits and consequent higher retail fresh citrus prices. Cold winter weather in Florida damaged the citrus crop, and fresh citrus usage fell 12.5 percent to 24.6 pounds per person.

Consumption of processed fruits was up slightly in 1981. Small declines in canned fruit and frozen fruit juices were offset by a 2.5-pound (15 percent) increase in canned juice consumption. Apple juice led the increase in canned juices with a 35-percent increase. The freeze in Florida reduced supplies of frozen orange juice concentrate and consumption of this item fell slightly despite higher orange juice imports.

Vegetables

Fresh vegetable consumption, excluding potatoes, fell 1.9 pounds in 1981 to 97.1 pounds per person. Consumption decreased for practically all vegetables except cauliflower, broccoli, carrots, and spinach. Fresh tomato consumption fell as supplies were reduced by poor winter weather and less harvested acreage. Retail fresh tomato prices were up 16 percent. Fresh potato usage declined to 47.1 pounds per capita in 1981 due to poor 1980 fall potato production.

Processed vegetable consumption was down 5 percent in 1981 to 57.2 pounds per person as per capita consumption of canned vegetables fell to 45.9 pounds, and per capita frozen vegetable usage rose 0.9 pound to 11.3 pounds. Most categories of canned vegetables were down in 1981, while all frozen items were up or unchanged. Frozen potato product usage increased 1.3 pounds per person to 18.2 pounds.

U.S. Demand for Meat

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Other Crop Products

Wheat flour consumption was steady in 1981 at 117 pounds per person. Usage of semolina and durum flour fell slightly to 5.7 pounds per capita, while that of white and whole wheat flour remained steady at 111 pounds per capita.

In 1981, Americans increased their rice consumption by 17 percent to a record 11 pounds per person. Historically, rice consumption has been erratic, but it has been increasing in the last two decades Production of rice has increased 58 percent since 1974 when production allotments were removed.

This increased production has found outlets in domestic consumption and exports. Three reasons Americans are eating more rice stem from increased promotional activities by rice producers, inflationary pressure on food budgets, and increased numbers of immigrants who are rice users.

Consumption of peanuts (excluding those for use in peanut oil) rose from 5.5 pounds per person in 1980 to 6.1 pounds in 1981. This was caused by record 1981 supplies as production recovered from the 1980 drought. Consumption of tree nuts (pecans, walnuts, etcetera) was up 0.2 pound to 1.9 pounds per person.

Sugar

Sugar consumption dropped 4.3 pounds per person in 1981, its fourth consecutive annual decline. Most of this drop is due to continuing competition from corn sweeteners in food manufacturing use. Per capita usage of corn syrups (wet basis) increased 6.1 pounds, with most of this gain coming from a 21-percent increase in high-fructose corn syrup.

Beverages

Per capita soft drink consumption is estimated to have risen 0.5 percent to 38 gallons in 1981. This continues a long upward trend, but the gain is smaller than in recent years. Consumption of coffee and tea at 7.7 and 0.8 pounds per capita, respectively, was basically unchanged in 1981. As reported by the Public Health Service, alcoholic beverage consumption was basically unchanged in 1981. ■

Consumers, in a 1980 USDA survey, said that they are eating less red meat due to health concerns. Yet, over the last decade, the per capita consumption of red meat has increased. This and other apparently contradictory observations led ERS researchers to ask to what extent consumer demand for meat can be explained by economic factors. The major finding: an overwhelming part of the variation in U.S. demand for meat can be explained by retail prices and income, indicating that noneconomic factors have played a relatively minor role in U.S. per capita meat demand.

Between 1973 and 1980, red meat consumption rose about 6 pounds per capita. Beef consumption decreased approximately 4 pounds per capita, but the 11-pound increase in pork consumption more than offset the decline in beef and other red meat consumption. Poultry consumption increased by about 11 pounds per capita, and fish consumption declined slightly. Over the period, fish prices increased 84 percent, veal prices increased 70 percent, beef prices increased 68 percent, and pork and poultry prices were up 28 and 21 percent respectively, while the price of nonfood items in the consumers' budget rose by 87 percent and consumer real incomes increased by 10 percent.

Examining these trends in combination can lead to confusion. Occasionally when year-to-year changes in prices and consumption of individual meats are studied, one observes seemingly contradictory behavior—such as a decline in price of a meat and a corresponding decline in consumption. The comprehensive demand model developed by ERS researchers takes into account a complete set of prices and income when measuring demand responses. Thus, it corrects some of the deficiencies inherent in partial approaches to explaining demand phenomena.

Demand Concepts and Measures

Consumers must decide how to use their limited incomes to purchase among a multitude of food and nonfood goods and services. The implication of this budgeting process is that the quantity demanded of each good and service is determined by three factors: the price of that good or service, the price of every other good or service, and the individual consumer's income. Consequently, the effects of changes in prices for nonfood items such as clothing or housing, while not dietary substitutes for or complements to meat, actually may have an important impact on consumer demand for meats and other food commodities. Thus, a comprehensive model that captures this complex decision process is necessary.

Answering the question of how much consumers would like to alter their consumption of meats in response to changes in prices and income requires linking observations on consumption to those on prices and income. The demand responses measured in this study are the responses attributable to a change in a particular good's own price, change in the price of another good, and a change in consumer income.

Frequently, there is a need to compare the demand responses to price and income for different commodities. For instance, is the demand for beef more responsive to a change in the price of poultry than vice versa? If it is, how much more responsive is it? If one were to select a price change of 10 cents per pound, the comparison might be misleading since 10 cents is a much higher proportion of poultry prices than it is of beef prices. The concept of demand *elasticity* is used in this study for comparison purposes to free the responses from different units of measurement. An elasticity measures the percentage change in quantity demanded of a good for a small percentage change in some price or income, *when all other prices and income are held constant.* For example the *cross-price elasticity* of beef, with respect to poultry, shows the percentage change in beef consumption resulting from a given change in the price of poultry. Demand responses can also be described in terms of *own-price elasticity* and *income elasticity.*

U.S. Demand for Red Meat, Poultry, and Fish

The elasticity estimates in table 1 were obtained from a statistical analysis that treated nonfood as a single item in the consumer's budget and disaggregated the food sector into a number of general commodity groups—red meats, poultry, fish, dairy products, fresh fruits, fresh vegetables, and the like. Since our focus is on the demand for meat and the number of demand elasticity estimates is quite large, the full set of demand responses obtained from the statistical analysis is not presented.

The demand elasticities of table 1 are the estimated own-price, cross-price, and income elasticities for the composite commodities of red meat, poultry, fish, and nonfood. These estimates are based on historical data for the period 1950–77. Quantities are USDA per capita consumption data, and composite price variables are Bureau of Labor Statistics (BLS) price indices for the corresponding commodity. Data through 1977 were used because post-1977 price-quantity data are not comparable.

Table 1 illustrates the quantity responses which result from changes in prices of meats, prices of other goods, and income. The numbers along the main diagonal (shaded area) are own-price elasticities. The first entry in the upper left corner (–0.677) is the estimate of the own-price elasticity of demand for red meats, which indicates that the average U.S. consumer decreased consumption of red meat by almost 0.7 percent in response to an isolated 1-percent increase in the price of red meat. The other entries along the diagonal are interpreted similarly. The own-price elasticities of demand also indicate that nonfood items are more demand-responsive to a change in their own price than are red meats, poultry, and fish. Red meat and poultry consumption is much more responsive to a change in their own price than the consumption of fish is to its own price.

The second number in the first row (0.098) is the cross-price elasticity of red meat with respect to the price of poultry. It shows that consumers increased their consumption of red meat by about 0.1 percent in response to a 1-percent increase in the price of poultry. The remaining cross-price elasticities in the first row are interpreted in a similar way. Consumer demand for poultry is particularly responsive to a change in red meat prices (0.565) but not to a change in fish prices (0.052). Demand for nonfood items is not very responsive to changes in prices of any one of the meat types as shown by the cross-elasticities in the last row of table 1. But, the demand for red meat, poultry, and fish is responsive to changes in the price of nonfood items. This can be seen by observing the cross-price elasticity estimates in the nonfood column of table 1. In fact, the impact of nonfood prices (0.103) on red meat consumption is greater than the impact of the fish price (0.012) and the poultry price (0.098). Also, a 1-percent increase in nonfood prices, other things equal, results in a decline (–0.356) in poultry consumption.

The last column of table 1 shows the estimated income elasticities for red meat (0.651), poultry (0.747), fish (0.549), and nonfood (1.206). The relative economic importance of nonfood in the budgeting process is indicated by its relatively large income elasticity, indicating that consumers will spend a larger portion of an additional dollar of income on nonfood items than they will on food. As incomes increase, consumers spend a smaller proportion of their budgets on red meats, poultry, and fish, and a higher proportion of their budgets on nonfood items.

Table 1. Red Meat, Poultry, And Fish: Elasticity Estimates From a Composite Demand System

Percent change in quantity demanded	1-percent price change					Income change
	Red meat	Poultry	Fish	Other food items	Nonfood	
Red meat	–0.677	0.098	0.012	—	.103	.651
Poultry	.565	–.886	.052	—	–.356	.747
Fish	.159	.120	–.053	—	.083	.549
Other food items	—	—	—	—	—	—
Nonfood	–.024	–.009	–.002	—	–1.026	1.206

— Indicates that elasticity estimates were obtained for other food items in the statistical analysis from which this table is extracted.

Structural Stability

To assess the extent to which consumer demand for meat can be explained by economic factors, the complete demand system represented by table 1, which takes into account all prices and incomes, was simulated for the 1950–77 period. This simulation indicated that over 95 percent of the variation in consumer demand for meat can be explained by the estimated economic structure based on retail prices and consumer income. This suggests that the demand system underlying the results presented in table 1 provides a good description of meat demand structure for the period covered. The major implication is that other noneconomic factors played a relatively minor role in explaining consumer meat demand during the 1950–77 period. ■

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Socioeconomic Characteristics and the Demand for Red Meats, Poultry, and Fish

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Income, race, family size and composition, region of residence, and urbanization are all important determinants of meat consumption, according to an analysis of the 1977-78 USDA Nationwide Food Consumption survey (NFCS). Meat consumed from home supplies—eaten at home or prepared at home and eaten elsewhere—was virtually the same on a per person basis, regardless of household income.

It is possible to isolate the influence of various demographic and economic phenomena using statistical techniques so that consumption behavior of various groups of consumers can be examined after adjusting for differences in demographics and economics. The statistical adjustments are necessary to isolate which factors cause which kinds of consumption behavior. With this information and knowledge about population, demographic, and economic trends, forecasters can make longer term projections of aggregate consumption.

Income

The degree to which a household adjusts its at-home meat consumption to changes in its income varies widely among meat products. Positive responses are found for those items which are typically higher priced, while negative responses are found for lower priced items. For example, a 1-percent increase in income is found to be associated with a 0.07-percent increase in at-home beef consumption and a 0.12-percent increase in at-home fish and shellfish consumption.

At the other end of the pricing scale, a 1-percent increase in income is associated with a 0.04-percent decline in at-home poultry consumption, and a 0.06-percent decline in at-home pork consumption. In addition to showing how households would respond to changes in income, the results in table 1 show that higher income households eat more of the higher priced meats and less of the lower priced meats than do the lower income households.

The study found that less pork and poultry is prepared or consumed at home as household income increases, even though overall pork and poultry expenditures tend to increase as income increases (see previous article). For these two measures to be consistent, away-from-home consumption of pork and poultry must increase enough to more than offset smaller at-home preparation and consumption.

Analyses of total food consumption behavior suggest that when household incomes go up or down, consumers make greater adjustments in food eaten away from home than for at-home consumption. However, data for individual meat items eaten away from home are not available.

Urbanization

Substantial variation in the amount of meat prepared or consumed at home exists, on a per capita basis, according to where a household is located. Illustrated in table 2 are the average weekly per capita meat consumption figures for a household residing in a central city. Also included are differences in meat consumption of suburban (SMSA, noncentral city) and nonmetropolitan consumers. After accounting for differences in family size and consumption, region, income, and race, those households living in suburban and nonmetro areas consume 7 percent and 9 percent less meat, respectively, from home supplies than those living in central cities.

Nonmetropolitan residents consume less of all meat categories except pork than do residents in central cities. The largest disparities exist for poultry (19 percent) and fish and shellfish (24 percent). Suburban residents consume 17 percent less chicken, and 13 percent less fish and shellfish per capita than do similar central city residents but 11 percent more turkey.

Region

Total at-home meat consumption varies little among regions. The difference between per person consumption in the Northeast and the West, the highest and lowest consumption regions respectively, is 10 percent. But large relative differences in consump-

Table 1. Consumer Response To A 1-percent Change In Income[1]

Item	Percent change in at-home quantity consumption due to a 1-percent increase in income
	Percent of change
Total meats	0.00
Red meats	.04
Beef	.07
Pork	-.06
Poultry	-.04
Chicken	-.05
Turkey	-.01
Fish and shellfish	.12

[1]Estimated from statistical analysis of 1977-78 NFCS.

Table 2. Variation In Weekly Per Person Home Meat Consumption, By Urbanization 1977-78[1]

Item	Central city	Suburban	Nonmetro
	Pounds	Percent of difference	
Total meats	4.86	-7	-9
Red meats	2.79	-3	-3
Beef	1.81	-4	-3
Pork	.89	2	2
Poultry	1.12	-13	-19
Chicken	.97	-17	-19
Turkey	.14	11	-20
Fish and shellfish	.43	-13	-24

[1]Estimated from statistical analysis of 1977-78 NFCS.

Table 3. Adjusted Weekly Per Person Home Meat Consumption, By Region, 1977-78[1]

Item	Northeast	Northcentral	South	West
	Pounds	Percent of difference		
Total meats	4.75	– 4	– 1	– 10
Red meats	2.74	4	0	– 5
Beef	1.74	9	– 2	2
Pork	.87	7	13	– 14
Poultry	1.13	– 25	– 7	– 22
Chicken	.96	– 25	– 5	– 22
Turkey	.16	– 24	– 16	– 16
Fish and shellfish	.39	– 27	13	– 11

[1]Estimated from statistical analysis of 1977-78 NFCS.

Table 4. Adjusted Weekly Per Person At-Home Meat Consumption, By Race, 1977-78[1]

Item	Nonblack	Black	Difference
	Pounds		Percent
Total meats	3.83	6.19	62
Red meats	2.34	3.23	38
Beef	1.53	1.94	27
Pork	.76	1.16	53
Poultry	.81	1.50	85
Chicken	.69	1.31	90
Turkey	.12	.19	61
Fish and shellfish	.30	.63	113

[1]Estimated from statistical analysis of 1977-78 NFCS.

tion are found for pork, chicken, turkey, and fish and shellfish. Fish consumption is highest in the South and lowest in the north central region, while pork consumption is lowest in the West and highest in the South. This suggests that regional differences are primarily due to substitution of one meat item for another, rather than substitution of meats for nonmeats.

Race

Racial differences have been found in many studies to be important determinants of food consumption patterns. By isolating racial differences and accounting for differences in income, region, degree of urbanization, and other demographic factors, it is possible to estimate the amount of meat consumption due solely to racial differences.

Results indicate that blacks consume 62 percent more total meat prepared or consumed at home than nonblacks, and in every meat category blacks consumed more per person than their nonblack counterparts. One reason for this finding may be the smaller number of meals eaten away from home by blacks. In the survey, it was noted that nonblacks ate about 12.5 percent of their suppers away from home while blacks ate only 7.5 percent.

Table 5. Net Effects of Household Composition on Per Person Weekly Home Meat Consumption, 1977-78[1]

Item	Standard consumer	Age group: 0-2	3-12	13-19	20-39	40-64	65 & over
	Pounds	Standard consumer equivalent					
Total meats	4.49	0.54	0.81	0.95	1.00	1.23	1.01
Red meats	2.75	.44	.74	.90	1.00	1.22	.99
Beef	1.79	.47	.73	.93	1.00	1.20	.93
Pork	.90	.38	.73	.84	1.00	1.22	1.02
Poultry	.90	.83	.99	.95	1.00	1.28	1.18
Chicken	.78	.82	.99	.94	1.00	1.24	1.19
Turkey	.11	1.14	1.20	1.08	1.00	1.61	1.09
Fish and shellfish	.38	.28	.48	.90	1.00	1.30	1.05

[1]Estimated from statistical analysis of 1977-78 NFCS.
[2]The standard consumer is taken as one in the age group 20-39. For example, a family composed of one 42 year-old adult, another 35 year-old adult, and two teenage children would consume an estimated 18.54 pounds of total meats at home in a week. This figure is calculated as follows: (1.23 + 1.00 + .95 + .95) x 4.49 = 18.54.

Household Composition

The number of persons comprising a household and the age composition of a household are found to be significant determinants of per capita meat consumption, and the kinds and types of meat products consumed or prepared at home. Differences in consumption patterns among households may stem from food choice, serving size, and the number of meals eaten or prepared at home. Table 5 illustrates the differences in the meat consumption of individuals by age group and can be used to estimate consumption for hypothetical households. An individual in the 20- to 39-year-old age group, is assumed to be the "standard consumer."

Individuals in other age groups are measured in relation to this base. To estimate the weekly consumption from home supplies of a household composed of two adults, aged 37 and 35, and a child aged 14, one would multiply the consumption of the base adult (4.49 pounds) by 2.95 (1.00 + 1.00 + 0.95). The result for this hypothetical household is 13.25 pounds.

Conclusions

The demand for red meats, poultry, and fish is shown to be significantly influenced by a household's socioeconomic characteristics. The results suggest that it is important for policymakers, producers, and processors to be aware of the influence of changing household size and composition, income, race, and regional population shifts on the demand for meat products. The results presented above and a more detailed analysis contained in the full report provides much of the information necessary to analyze the effects of these factors on consumer demand for meat. ■

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Changes in Fuel Costs and Vegetable Prices

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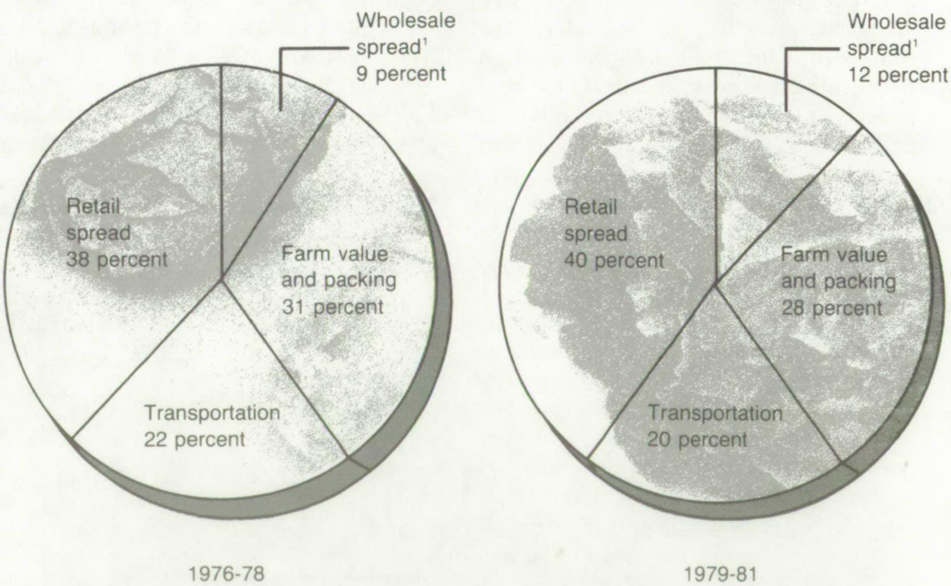
Trucks are the primary carriers of the Nation's fresh vegetables. Their favorable combination of cost, flexibility, and transit time relative to other transport modes, make them the preferred carriers for these movements. In 1981, about 89 percent of U.S. vegetable shipments moved in trucks. Many of these hauls were transported from California, Florida, and Texas, which accounted for 62 percent of U.S. vegetable production in 1980, to markets in the East and other parts of the country.

Estimates show that truck fuel costs per mile traveled increased about 17.7 cents per mile from 1976 to 1981. But, this increase in fuel prices appears to have contributed only slightly to recent vegetable price increases. For example, fuel costs represent only 5 to 6 percent of the retail price of lettuce in New York. If fuel costs doubled, the retail price of a 75-cent head of lettuce would only increase about 4 cents (if other price components remained unchanged). Also, it is unlikely that increases in transportation fuel prices in the near term will create adequate economic incentives to shift vegetable production closer to consumers.

One way of isolating the impact of higher fuel costs is to compare the proportion of vegetable marketing spreads accounted for by transportation fuel costs, over time. Lettuce was selected as a proxy for vegetables because it is the principal fresh vegetable produced in the United States. It accounts for almost one-fourth of the volume of vegetables produced, and 18 percent of the dollar value of vegetables produced. In 1980, California and Arizona produced about 88 percent of the U.S. fresh market lettuce. California alone, accounted for 68 percent. About 80 percent of the lettuce shipped to New York was grown in California.

Fuel cost affects vegetable prices through its effect on trucking costs. Costs of trucking fall into two categories: fixed overhead costs, such as equipment, depreciation, insurance, capital costs, and taxes, which do not change much with the volume of

Figure 1. Relative Cost Components of New York Retail Lettuce



[1]Excludes farm-to-wholesale transportation, farm value, and packing.

Table 1. Estimated Per Mile Truck Costs[1]

Cost item	1976		1981		Change 1976 to 1981
	Cents per mile	Percent	Cents per mile	Percent	Percent
Driver	19.0	32	30.4	28	60
Fuel	11.6	20	29.3	27	153
Vehicle depreciation	6.7	11	11.4	11	70
Interest	2.7	5	8.5	8	215
Other[2]	18.6	32	28.6	26	54
Total	58.6	100	108.2	100	85

[1]Truck fleet.
[2]Includes management cost, license fees, maintenance and other miscellaneous costs.

Source: USDA's Office of Transportation.

business conducted during a year; and variable costs, such as fuel expenses and drivers' wages, which are greatly influenced by miles driven and the amount shipped.

Total costs per mile for operating refrigerated-fleet trucks increased 85 percent between 1976 and 1981, from an estimated 58.6 cents per mile to 108.2 cents (table 1). There was a 153-percent jump in diesel fuel cost which climbed from 11.6 cents per mile to 29.3 cents. Drivers' wages and fringe benefits, still the largest cost component, increased 60 percent from 19 cents to 30.4 cents per mile. Other components, such as vehicle depreciation and interest, gained 70 percent and 215 percent respectively. Other costs rose 54 percent.

Fuel now accounts for about 27 percent of the average per mile cost of trucking vegetables, compared with a 20-percent share in 1976 (table 2). The share of per mile costs for wages fell from 32 to 28 percent in the same period, while vehicle depreciation's share remained the same at 11 percent (table 1). Interest's share rose from 5 to 8 percent, and in the "other costs" category, the share fell from 32 to 26 percent.

Differences between the farm and wholesale prices—the wholesale spread—approximate transportation costs between the shipping point near or at the farm and the wholesaler, plus the wholesaler's costs (distribution, handling, and other costs). Differences between wholesale and retail prices—the retail spread—approximate retailing costs. By dividing the typical farm-to-retail spread in this way, long distance transportation costs, wholesale costs, and retail costs can be separated out. This permits a comparison of changes in these components with changes in retail prices. However, the subsequent long distance trucking cost component is not derived from the wholesale spread, but is computed from actual trucking rates for vegetables.

While truck rates for California lettuce sold in New York rose 70 cents per carton from 1976 to 1981, the wholesale spread increased $1.03. The retail spread increased $4.01.

Table 2. Fuel Cost Expressed As A Percentage Of Total Truck Costs[1]

Year	Percent of per mile cost
1976[2]	20
1979	25
1980	26
1981[3]	27

[1]Costs for a truck fleet.
[2]June-December
[3]January-November

Table 3. Relative Components Of the Retail Price, New York Market

Year	Retail spread	Wholesale spread[1]	Transportation	Farm value	Total
			Percent		
1976	35	9	24	32	100
1977	43	8	24	25	100
1978	35	11	19	35	100
1979	41	13	19	27	100
1980	36	15	22	27	100
1981	45	7	19	29	100

[1]Wholesale price minus shipping point price and transportation.

The relative shares of the several cost components, expressed as a percentage of the retail price, also changed over this period (table 3). The average retail spread for 1976–78 versus 1979–81 increased from 38 to 40 percent of the retail price (figure 1). The average wholesale spread (excluding farm-to-wholesale transportation) increased from 9 to 12 percent of retail price. The farm value component decreased from 31 to 28 percent, while transportation declined from 22 to 20 percent.

Transportation costs' declining share of retail lettuce prices means that long distance trucking costs actually became less of a factor in the prices consumers paid for lettuce. Even while fuel costs and total transportation costs were increasing, transportation's share declined five cents for each dollar spent by consumers on lettuce due to proportionately larger increases in the retail price and marketing cost components other than long distance transportation.

Even if the data indicated a much higher potential impact of fuel price increases on retail lettuce—by implication, all vegetable prices—it is questionable whether farms closer to cities could ever become sufficiently competitive with the major producing areas to meet the demand for fresh vegetables. Present producing areas enjoy climatic advantages which allow year-round production and substantial economies due to specialization and farm size. Moreover, expansion of vegetable production around metropolitan areas would require a significant increase in acreage. Much of this land is now in alternative uses which offer higher returns than in vegetable production. Climate restrictions further reduce production potential for many areas. Major cost-reducing technological breakthroughs would be needed to make large scale, year round vegetable production economically feasible in areas close to major cities in the northern half of the United States.

With all economic factors considered, it is unlikely that near term transportation fuel cost increases alone will cause major shifts in fresh vegetable production—especially to areas near large metropolitan centers. ■

Food Expenditure Revisions: 1977-81

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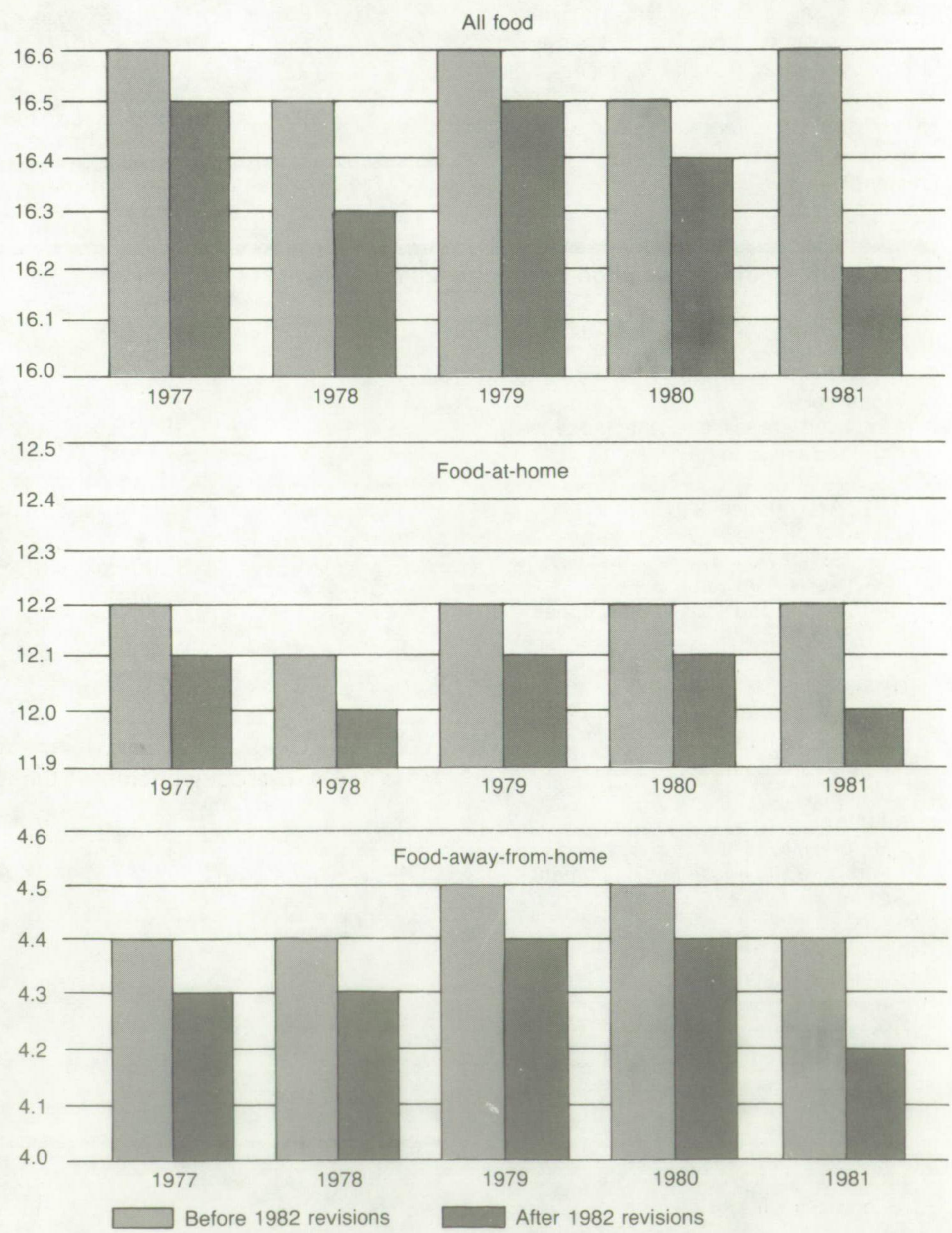
The U.S. National Income and Product Accounts series, published by the Department of Commerce, is a leading indicator of food spending in the United States. Periodically, this series is revised. The most recent revisions, released in July, reflect new data and methodological changes.

Revisions for 1977 through 1981 resulted in several significant changes:

- Personal income of Americans was higher than previously estimated.

Figure 1. Portion of Disposable Personal Income Allocated to Food, Before and After 1982 Revisions



- Personal consumption expenditures were revised down with more than half of the decline occurring in services.
- Durable goods expenditure estimates were revised upward.
- Higher estimated income and the lower spending rate resulted in higher estimates of savings. For 1981, the revised estimate of savings was $130.2 billion, 22 percent higher than the previous estimate of $106.6 billion.
- Americans spent a smaller portion of disposable income on food. For food consumed at home and away from home, figures were less than previously calculated. Total food spending for 1981 was calculated at $329 billion rather than the previous estimate of $337 billion. ■

Figure 2. Index of Personal Consumption Expenditures for Food, Adjusted for Price and Population Increases (1976=100)

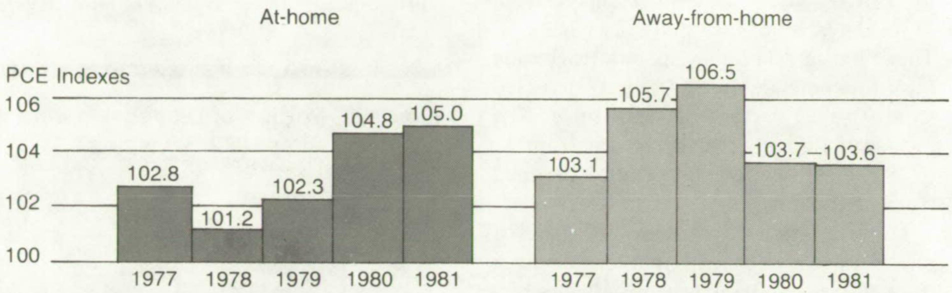


Table 1. Personal Consumption Expenditures: Annually, 1977-81

Item	1977	1978	1979	1980	1981
	Billion dollars (current)				
Total personal consumption expenditures	1204.4	1346.5	1507.2	1667.2	1843.2
Nondurables	478.8	528.2	500.0	670.4	734.5
Food, beverages, and other groceries[1]	291.9	321.8	362.1	398.5	435.9
Food exc. alcoholic beverages	217.4	240.9	272.2	300.0	329.1
At home	160.4	177.0	199.8	221.5	242.9
Away from home	57.0	64.0	72.5	78.4	86.1
Alcoholic beverages	32.5	34.9	39.3	43.7	46.2
At home	20.7	22.0	24.8	27.7	28.8
Away from home	11.8	12.9	14.5	16.0	17.4
Cleaning and household supplies	14.3	15.7	17.6	19.4	21.4
Toiletries	11.2	12.3	13.6	14.7	16.1
Tobacco	16.6	18.0	19.3	20.7	23.1
Drugs	12.9	14.2	15.8	17.1	18.6
Clothing and shoes	82.6	92.4	99.1	104.7	114.6
Gas and oil	48.1	51.2	66.6	87.0	96.8
Fuel oil and coal	10.7	11.9	16.1	19.0	19.7
Other	32.6	36.7	40.4	44.1	48.9
Durables	178.2	200.2	213.4	214.3	234.6
Motor vehicles and parts	84.8	95.7	96.6	89.7	98.6
Furniture and household equipment	65.7	72.8	81.8	86.3	93.4
Other	27.7	31.7	35.1	38.3	42.6
Services	547.4	618.0	693.7	782.5	874.1
Housing	185.9	209.6	236.1	266.0	295.3
Household operation	81.1	90.1	99.3	111.7	128.9
Transportation	46.4	51.2	56.3	62.9	65.4
Personal care	12.6	14.0	15.2	16.6	17.4
Medical care	96.5	108.4	124.1	143.5	170.9
Personal business service	60.7	72.6	83.7	93.7	99.8
Recreational services	26.0	29.3	31.7	35.2	38.6
Other	38.3	42.8	47.3	52.9	57.7
Savings	78.0	89.4	96.7	106.2	130.2
Disposable Personal Income	1314.0	1474.0	1650.2	1824.1	2029.1

[1]Contains some items not normally purchased in grocery stores.

Table 2. Allocation of Personal Income: Annually, 1977-81

Item	1977	1978	1979	1980	1981
			Percent		
Total personal consumption expenditures	91.7	91.3	91.3	91.4	90.8
Nondurables	36.4	35.8	36.4	36.7	36.2
Food, beverages, and other groceries[1]	22.2	21.8	21.9	21.8	21.5
Food exc. alcoholic beverages	16.5	16.3	16.5	16.4	16.2
At home	12.2	12.0	12.1	12.1	12.0
Away from home	4.3	4.3	4.4	4.3	4.2
Alcoholic beverages	2.5	2.4	2.4	2.4	2.3
At home	1.6	1.5	1.5	1.5	1.4
Away from home	0.9	0.9	0.9	0.9	0.9
Cleaning and household supplies	1.1	1.1	1.1	1.1	1.1
Toiletries	0.8	0.8	0.8	0.8	0.8
Tobacco	1.3	1.2	1.2	1.1	1.1
Drugs	1.0	1.0	1.0	0.9	0.9
Clothing and shoes	6.3	6.3	6.0	5.7	5.6
Gas and oil	3.7	3.5	4.0	4.8	4.8
Fuel oil and coal	0.8	0.8	1.0	1.0	1.0
Other	2.5	2.5	2.4	2.4	2.4
Durables	13.6	13.6	12.9	11.7	11.6
Motor vehicles and parts	6.5	6.5	5.9	4.9	4.9
Furniture and household equipment	5.0	4.9	5.0	4.7	4.6
Other	2.1	2.1	2.1	2.1	2.1
Services	41.7	41.9	42.0	42.9	43.1
Housing	14.1	14.2	14.3	14.6	14.6
Household operation	6.1	6.1	6.0	6.1	6.4
Transportation	3.5	3.5	3.4	3.4	3.2
Personal care	1.0	0.9	0.9	0.9	0.9
Medical care	7.3	7.4	7.5	7.9	8.4
Personal business service	4.6	4.9	5.1	5.1	4.9
Recreational services	2.0	2.0	1.9	1.9	1.9
Other	2.9	2.9	2.9	2.9	2.8
Savings	5.9	6.1	5.9	5.8	6.4
Disposable Personal Income	100.0	100.0	100.0	100.0	100.0

[1]Contains some items not normally purchased in grocery stores.

Domestic Food Programs

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Preliminary data indicate that Federal expenditures for USDA-supported feeding programs fell from $4.5 billion in the first 3 months of 1981 to $4.1 billion in that period this year. The only increase in participation was in the Commodity Supplemental Food Program.

The largest decrease in the number of participants was in the School Breakfast Program (SBP). The number decreased from an average of 3.9 million in the first quarter of 1981 to 3.3 million in the first quarter of 1982, a decline of 13.5 percent. Program costs also fell—by 8.1 percent—from $108.1 million to $101.2 million. Participation in the Child Care Food Program (CCFP) and National School Lunch Program (NSLP) fell by 12.3 and 11.1 percent, respectively. Expenditures for the CCFP fell from $75.9 million in the first quarter of 1981 to $69.1 million in the same period in 1982. Expenditures for the NSLP declined from $778 million to $709 million.

Higher meal prices, stricter eligibility criteria, and declining school enrollments are responsible for the significant decreases in participation. The number of private schools offering child nutrition programs has declined because of tuition restrictions that became effective on October 1, 1981. Private schools with average annual tuition of $1,500 per child became ineligible to participate.

Stricter eligibility guidelines are also responsible for a 1.8-percent reduction in FSP participation between the first quarter of 1981 and the same period in 1982. The number of people receiving stamps declined from 22.7 million to 22.3 million.

The average bonus per person also fell during this period from $41.78 to $39.41. The decline is attributed to a provision of the Omnibus Reconciliation Act of 1981 which requires that the value of the food stamp allotment to each household be prorated during the initial month. Previously, a household received the full value of the monthly allotment regardless of what day during the month they were certified as eligible for program benefits. By prorating, a household certified on the 15th of the month receives stamps equal to only one-half of the total value of the allotment.

The Special Supplemental Food Program for Women, Infants, and Children (WIC) provides food assistance and nutrition education to low-income mothers and young children. Average participation in the program fell by 4 percent between the first quarter of 1981 and the same three months in 1982, from 2.2 million to 2.1 million. Total expenditures for the program increased, however, from $232.1 million in the first quarter of 1981 to $237.1 million in 1982. While expenditures for food for the program declined from $187.3 million to $184.9 million between the first quarters of 1981 and 1982, administrative costs increased from $44.8 million to $52.2 million. This

Table 1. Federal Cost of USDA Food Programs

ITEM	1979[1]	1980	1981	1981				1982[2]		
				1	2	3	4	1	2	3
				Million Dollars						
Food stamps										
Total issued	7111	9004	10968	2856	2817	2698	2597	2647	2601	2361
Bonus stamps	7108	9004	10968	2856	2817	2698	2597	2647	2601	2361
Food distribution[3]										
Needy families	22.2	23.5	33.0	12.2	6.3	6.1	8.4	25.9	31.1	25.0
Schools[4]	720	967	825	328	160	116	221	259	118	112
Other[5]	85	115	108	29	29	25	24	40	41	28
Child nutrition[6]										
School lunch	2101	2395	2286	778	569	271	667	709	528	290
School breakfast	243	311	331	108	84	43	97	100	78	45
Special food[7]	288	338	400	76	97	155	72	67	81	139
Special milk	146	137	73	34	25	8	5	6	5	5
WIC[8]	569	783	869	232	209	214	214	237	244	264
Total[9]	11283	14075	15892	4454	3995	3537	3906	4092	3726	3269

[1]Annual totals computed from monthly data beginning with 1979. Previously obtained from quarterly data supplied by FNS.
[2]Preliminary.
[3]Cost of food delivered to State distribution centers.
[4]Includes Child-Care and Summer Food Service Programs.
[5]Includes Supplemental Food, Nutrition Program for the Elderly and donations to charitable institutions.
[6]Money donated for local purchase of food. Excludes nonfood assistance.
[7]Includes Child-Care and Summer Food Service Programs.
[8]Special Supplemental Food Program for Women, Infants, and Children. Includes food and administrative costs.
[9]Excludes those food stamps paid for by the recipient.

increase may be attributed to a change in the funding formula for administrative costs.

The Child Nutrition Amendments of 1978 require that 20 percent of the total funds, excluding those funds set aside for program evaluation, be made available for State and local administrative expenses associated with WIC program operations. An October 1980 provision allows State agencies with excessive administrative expenses to receive additional administrative funds. In fiscal year 1981, 12 State agencies were granted funding increases.

Foods are also donated to low-income mothers and young children who do not participate in the WIC program, under the Commodity Supplemental Food Program (CSFP). (For a description of the two programs see NFR-17, Fall 1981.) Average participation in the CSFP rose by 4.5 percent between the first three months of 1981 and the same period in 1982—from 115,905 to 121,142. Greater amounts of commodities have been made available through the program, thereby increasing the number of persons that can participate. Greater participation in the Commodity Supplemental Food Program resulted in a slight increase in program expenditures of $100,000 from the first quarter of 1981 to $6.3 million in the first quarter of 1982.

The most startling reductions in program size occurred in the Special Milk Program (SMP). The Omnibus Reconciliation Act of 1981 limits participation in the SMP to schools which do not participate in a meal service program authorized under the National School Lunch Act or Child Nutrition Act of 1966. As a result, the number of schools offering the program was reduced from 84,488 in March 1981 to 6,773 in March 1982. The number of half pints of milk served in schools fell from 507 million in the first quarter of 1981 to 59.6 million in the first quarter of 1982. The number served in child care institutions showed only a small decline during the same period—from 673,000 to 591,500. Federal expenditures for the SMP were reduced from $34.2 million in the first three months of 1981 to $5.7 million in the same period in 1982. ■

Impacts of the Staggers Rail Act

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The Staggers Rail Act of 1980 substantially revised the regulatory climate for U.S. railroads. While this act is still being interpreted by the Interstate Commerce Commission (ICC), it has already altered the mix of transport services available to food and commodity shippers due mostly to provisions of the act concerning rail line abandonment. Also, railroads now have greater freedom in setting rates and can enter into shipping contracts with individual shippers.

Prior to the Staggers Act, railroads normally sought ICC approval for freight rate increases based on actual costs experienced in prior months. But, as costs continued to increase, rates tended to lag behind. To eliminate this problem, the ICC developed an index method of determining costs. The Rail Cost Recovery Index combines the actual costs of the past quarter with any anticipated cost increases for the next quarter. If the index forecasts an increase, railroads are permitted, although not required, to raise their published rates by the indicated percentage. However, if a decrease is forecast, railroads are not required to drop their rates.

For example, in January 1982, the Rail Cost Recovery Index indicated an increase in first-quarter expenses of 4.7 percent. Most railroads boosted freight rates for grain by that percentage and increased other shipping rates as well. Average rates for manufactured food products increased by 4.1 percent; all commodities (farm and nonfarm) by 3.6 percent; and farm products by 4.2 percent. However, when a 2-percent decline in costs was forecast for the second quarter of 1982, railroads did not institute widespread reductions.

In all but one of the years 1975 to 1981, rail rates increased more rapidly than the Consumer Price Index (CPI), a commonly used measure of cost increases. Rate increases were greater both immediately before and after passage of the Staggers Act. In 1979, rates increased 27 percent more than the CPI: they were 25 percent higher in 1980 (the year Staggers became law) and were 46 percent more in 1981. Generally, the annual shipping rate increases for food and farm commodities exceeded the average increases for all rates.

The Staggers Act also permits railroads to offer short-term discounts to shippers. Throughout 1981 and continuing into 1982, grain shippers received substantial discounts on specific routes for periods of 30 to 90 days when surpluses of rail cars existed.

Some shippers find fault with this practice, however, since the lack of uniformity and rate instability make it difficult to determine the least costly route to a particular destination. Such shippers may be interested in using contracts, now possible because the Staggers Act specifically allows railroads to enter into contracts with individual shippers. On March 1, 1982, 101 contracts for food and agriculture were in

Table 1. Increase In Annual Consumer Price Index and Average Rail Rates

Index	1975	1976	1977	1978	1979	1980	1981
				Percent of increase			
Consumer Price Index	9.1	5.8	6.4	7.6	11.2	13.5	10.4
Commodity groups:							
All rates	13.2	10.2	6.7	7.0	14.2	16.9	15.1
Farm products	13.6	10.7	4.7	7.1	15.1	16.8	14.2
Grain	—	—	—	—	—	19.1	15.8
Food products	13.2	9.8	5.5	7.5	13.9	18.3	16.4

— not available

Source: Bureau of Labor Statistics, U.S. Department of Labor effect: 45 for grain, 49 for food products, 5 for fertilizer materials, and 2 for animal feed. These contracts offer relatively low charges for large-volume shipments of 25 to 100 cars.

Contracts are also made for smaller shipments but these are always limited to those on heavily-traveled routes. A majority of contracts involving food products apply to bulk items such as sugar, flour, and cooking oil, but several have been made for canned food.

The result of the rate and contract regulations is a two-level rate structure. Frequent, large-volume shipments have relatively low contract rates, while small shipments and those to remote points move at higher rates.

Although Federal regulation of railroads has always included provisions that allowed unprofitable branch lines to be retired from service, the formal abandonment procedures conducted by the ICC set no time tables. As a result, some abandonments were tied up in expensive regulatory compliance problems for more than 10 years. This caused railroads to continue operating unprofitable lines or to simply not use parts of their lines, without formally abandoning them. Despite this, total rail line mileage has steadily declined over the past five decades (see table 2).

Although the Staggers Act did not significantly change the standards for abandonment, it imposed time limits on the various required proceedings. Uncontested applications now must be decided by the ICC within 75 days, and no more than 255 days can elapse between the filing date and final decision date for most other applications. As a result, the pace of applications for abandonments has increased.

In the 18 months prior to enactment of the Staggers Act, abandonment applications were filed for 7,421 miles of rail line (table 3). Since 3,684 miles were due to the bankruptcy of the Milwaukee Railroad, the remaining 3,737 miles can be attributed to normal abandonment procedures. In the 18 months folling passage of the Staggers Act, abandonment applications for 6,581 miles were filed. Of these, 2,117 miles probably resulted from passage of the Northeast Rail Service Act of 1981, dealing chiefly with CONRAIL. Thus, abandonment requests for 4,464 miles could be directly attributed to the Staggers Act provisions, a 62-percent increase over the prior 18-month period.

Many of the lines for which applications have been filed are not main railroad lines but branches. While branch-line abandonment applications are not expected to continue indefinately at the current rate, there is no indication that filings will decline this year.

While these eliminations of unprofitable assets have strengthened the finances of the railroads, they also reduce intermodal competition and availability of rail service to some farm commodities. The abandonments can also be expected to increase distribution costs for input suppliers and commodity shippers located on abandoned lines. Loss of rail services to an individual shipper or receiver generally results in the use of relatively costly truck service. ■

Table 2. Railroad Line Mileage, Average Annual Miles Lost, 1929-79, Selected Years

Year	Line mileage	Average line mileage lost per year[1]
1929	249,433	—
1939	235,064	1,437
1947	225,806	1,157
1955	220,670	642
1965	211,925	874
1975	199,126	1,280
1979	184,500	3,656
1982	—	3,271[2]

— not available

[1]Rail line lost through bankruptcies and abandoments over the intervening years.
[2]Actual miles abandoned in 14 selected States during the first quarter.

Source: Association of American Railroads and USDA's Office of Transportation.

Table 3. Rail Line Abandonments Filed During Selected 3-Month Intervals, 1979-82

Intervals	All railroads
	Miles
5/1/79-7/31/79	358
8/1/79-10/31/79	2,267
11/1/79-1/31/80	635
2/1/80-4/30/80	2,206
5/1/81-7/31/80	949
8/1/80-10/31/80	1,006
11/1/80-1/31/81	675
2/1/81-4/30/81	759
5/1/81-7/31/81	926
8/1/81-10/31/81	1,033
11/1/81-1/31/82	2,731
2/1/82-4/30/82	457

Source: USDA's Office of Transportation.

United States
Department of Agriculture
Washington, DC 20250

OFFICIAL BUSINESS Penalty for private use, $300

NFR-20

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