Food Preservation and Nutrition

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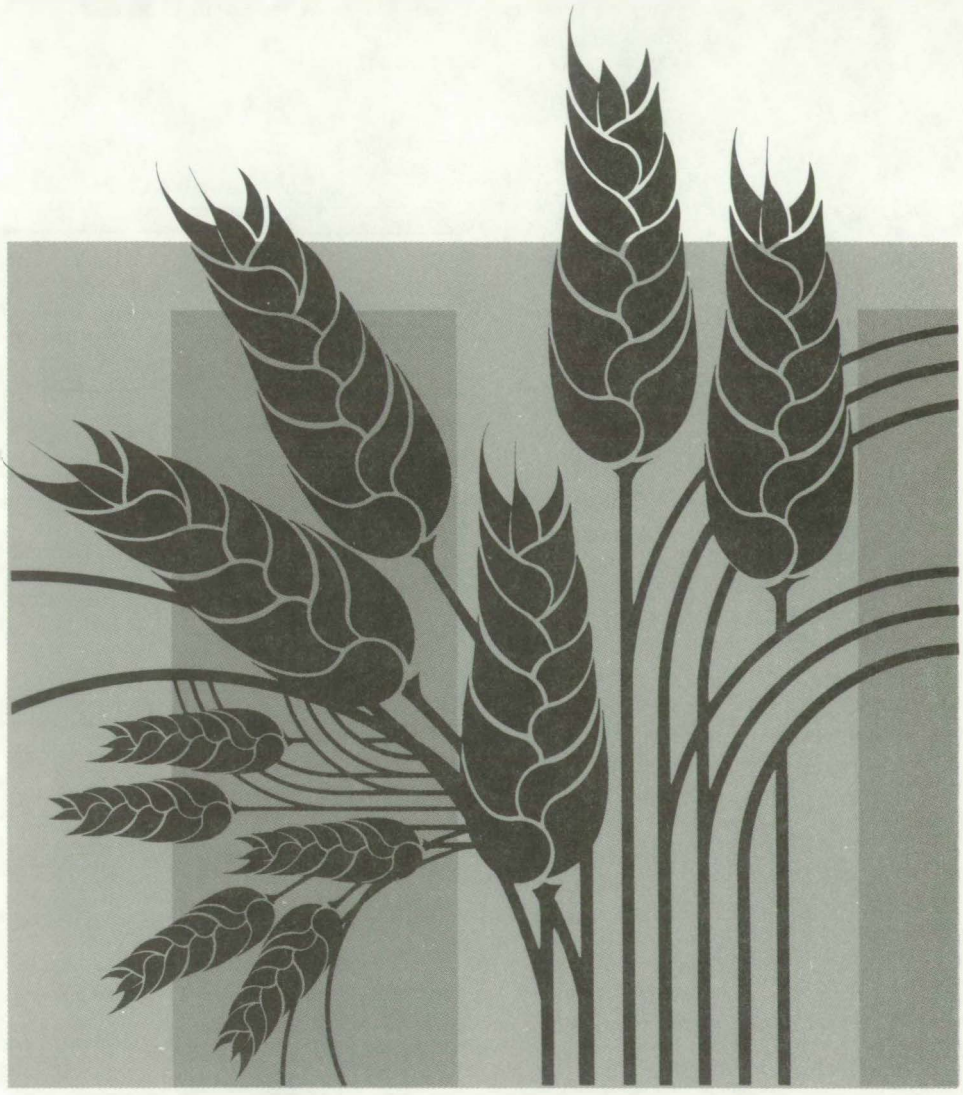


Indians living in the Peruvian Andes 3,000 years ago were the first known food preservationists, drying potatoes to eat in winter and spring. Food preservation techniques have come a long way since then, but the first "modern" breakthrough occurred in 1809 when Nicolas Appert developed a canning process 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.

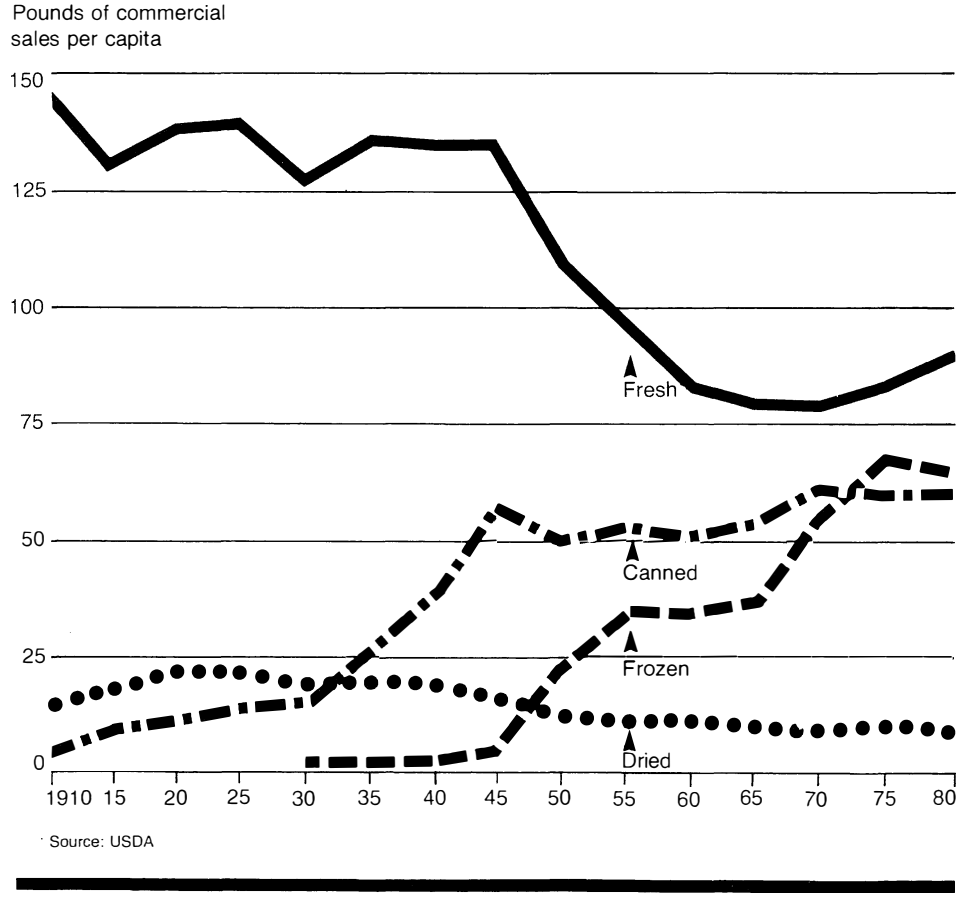
Both canning and freezing use similar amounts of energy. The higher energy use during freezer storage is generally offset by the lower energy use in manufacturing the freezer package versus the tin can. The multitude of processing equipment manufacturers, production line peculiarities, and the different 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

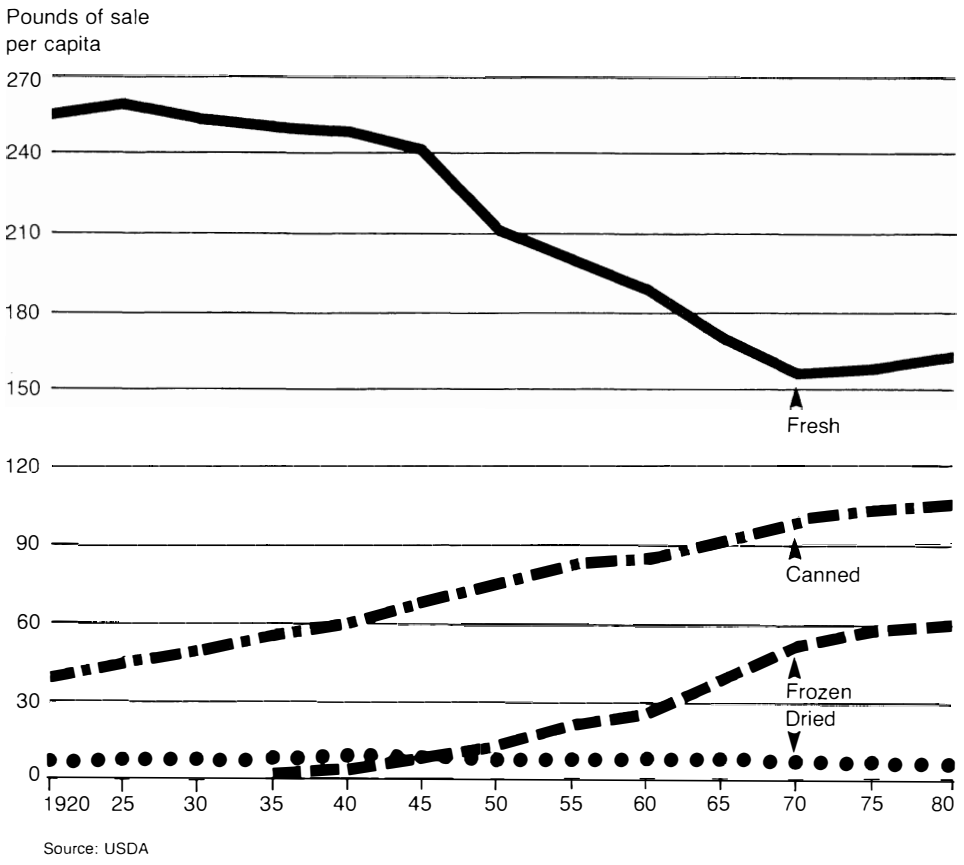
Dehydration. Drying improves the storage life of foods by depriving microorganisms of sufficient water to grow and reducing the rate of enzyme activity and chemical reactions. The Food and Container Institute, under contract to the U.S. Armed Forces, experimented with hot air drying, vacuum drying, spray 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 airtight 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.)

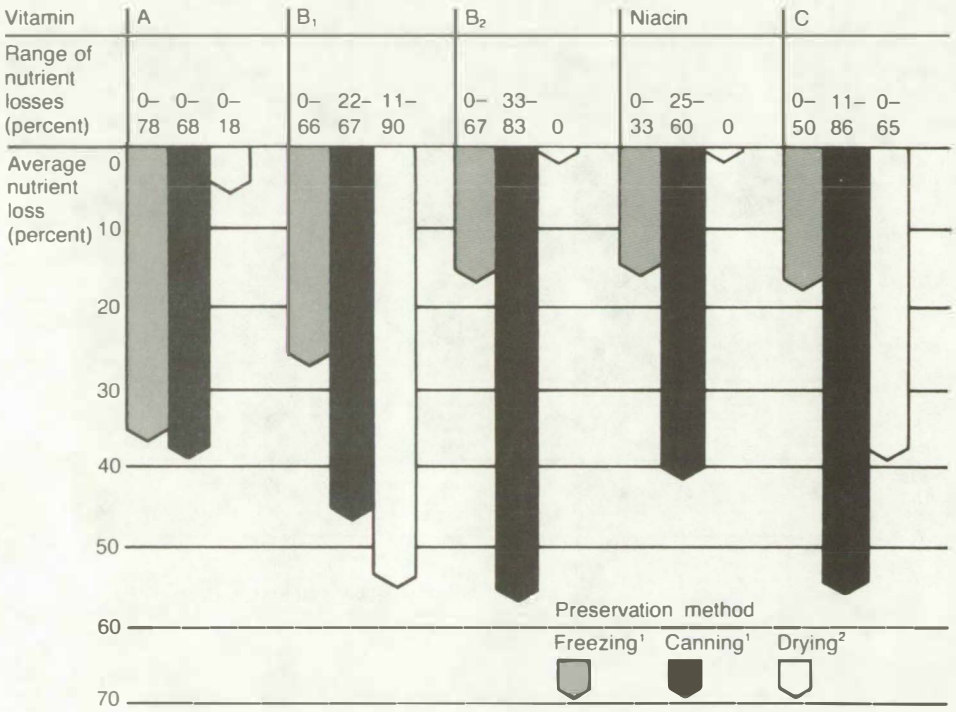
Freezing is generally regarded as the best method of long-term food preservation in terms of retaining sensory attributes and nutrients, but it causes water soluble vita-

mins 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

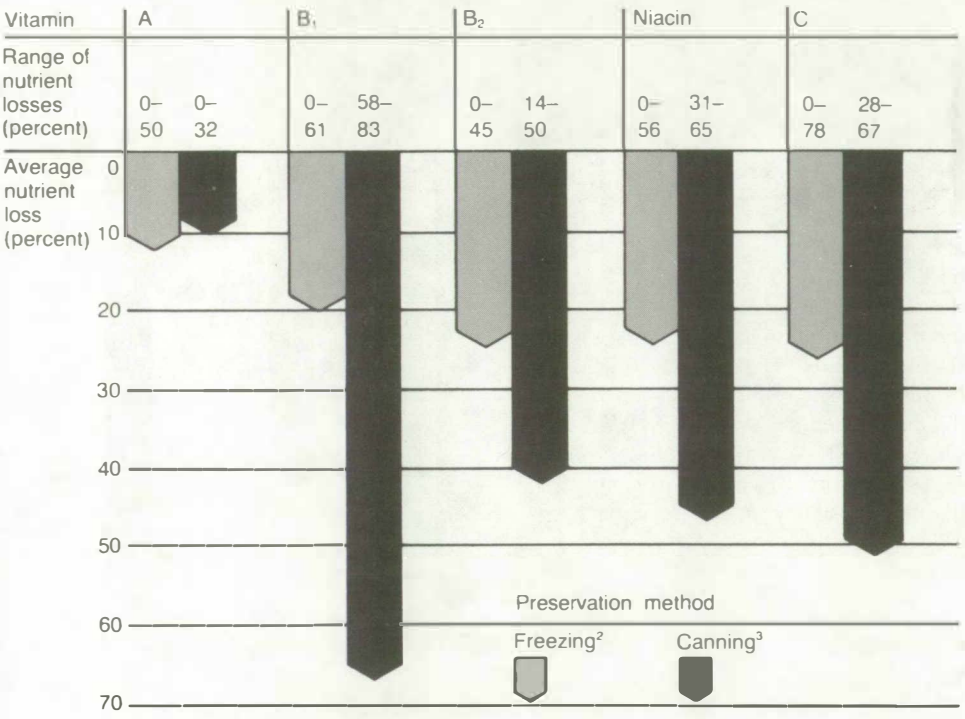
The nutritional value of raw foods varies considerably from one batch to another, due to location, weather, agricultural practices, soil composition, and genetic stock. For example, Atlantic oysters are more nutritious than Pacific oysters. On a per calorie basis, Atlantic oysters contain 10 percent 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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