Processing and Preservation

by ROBERT L. OLSON and CLYDE L. RASMUSSEN

IF WE COULD NOT PRESERVE food in some stable form, people would forever be forced to live right where the food is produced, and there would be no agricultural trade.

Canning, freezing, dehydrating, refining, extracting, and salting all make foods stable and transportable. Even such fresh foods as fruit, vegetables, and meat can be shipped great distances because they are preserved by refrigeration. Meat is shipped from Australia to England, oranges from California to Germany, and apples from South Africa to Sweden.

A major part of the food in world export has only simple or primary preservation—for example, natural sun drying of cereals and preliminary separation of sugar and extraction of vegetable oils without final refinement.

At destination, those products require further processing. This practice lowers the cost of food in international trade; labor and other resources of the importing nation are used in the final processing.

New products and processes, however, have contributed greatly to the growth in trade and will be even more important in the future.

Processed food—canned, frozen, and dried fruit, frozen poultry, dairy products, and many more—are an important part of the annual commercial agricultural exports, worth 4 billion dollars in 1964, of the United States. The high quality of processed food from the United States places them on the preferred lists of many people.

The retention of markets for processed food will depend to a big extent on the ability of American processors to improve quality further, reduce costs, and develop new products for a growing market for luxury products that may accompany economic improvement in western Europe.

The long-range existence of markets for preserved foods is by no means assured, however.

Agricultural self-sufficiency is a declared policy of the European Economic Community and other countries whose resources permit it. The technologies of production and processing of foods are largely transmissible, and cost advantages that may exist in their application anywhere can be counterbalanced by protective tariffs. An example is a severalfold increase in tariff on frozen poultry in 1963 that severely reduced United States shipments to the Common Market countries.

The continuation of United States commercial export markets must fit into the pattern of a growing self-sufficiency in other countries.

Oilseeds, feed concentrates for livestock, and strong wheats for bread do not seem likely to be abundantly produced in Europe, but resources there are well adapted to the production of other commodities. Markets for such crops may well increase and help counterbalance the reduction in markets for canned fruit, softer wheats, and animal products, especially frozen poultry.

Many American food processors have established European bases for their operations to preserve hard-won markets for their brand-named products. Japan and the United Kingdom have been an expanding market for American food because the growth of population and resources of land and climate limit the possibility of agricultural self-sufficiency.

Special Government programs provided export markets for about 2 billion dollars' worth of agricultural goods in 1964, primarily wheat, rice and cereal products, vegetable oil, and dried milk. An improvement in the economic status of the developing countries, the recipients of the exports, may transform those markets eventually into commercial markets. If so, it follows that they also will develop a demand for processed food.

The use of processed food is greatest in countries that are most fully developed economically. For example, more than 90 percent of the food consumed in the United States is transported to markets away from the farm and processed, preserved, or packaged in some way before it is consumed. Even though factory wages, transportation rates, and other costs of manufacturing and distributing have increased, retail prices of food have remained relatively stable, thanks to the strides made in mechanization and the application of research to all aspects of growing and processing.

We spent less than one-fifth of our disposable income for food in 1964; it was one-fourth in 1950. A point even more startling is that only one-seventh of our disposable income today would be used for food if we ate diets identical to those of a generation ago and processed in the same manner. The reason for that is that we have many new foods and convenient ways to prepare them.

IN THE GENERAL division of the world between regions that have abundant food and those that do not, the former have well-developed food-processing technologies and also a high level of specialization in food production.

Processing for convenience has become perhaps more important than for preservation alone.

The less-developed regions generally have primitive processing facilities at best and are forced to a large degree to live where the food is produced.

Processing generally is only to keep food for consumption in the off seasons.

People are plentifully supplied with the perishable commodities (such as fruit and vegetables) only during harvest seasons.

Neither the production nor the preservation of food in those regions has achieved the efficiency of modern technology that is necessary to sustain the material wealth of urbanized civilization. The preservation of food in small factories yields expensive luxuries for the wealthy, in contrast to the mass-produced, low-cost foods for all classes in the urbanized countries. Processing tends to be minor and simple. The bulk of the food supply is made up of a few basic items.

THE LESS-DEVELOPED nations are expected to follow the patterns of food-processing advancement of the past two centuries in other parts of the world. Such an advancement will not be easy.

At the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas in Geneva in 1963, some of the difficulties were outlined in the *Summary of Proceedings on Agriculture*.

It stated: "A lack of knowledge of good food habits and of satisfactory domestic preservation, processing, and storage of foodstuffs is the rule rather than the exception in less developed countries. Trained professional and auxiliary staff, with a sound scientific and practical knowledge of nutrition, working in the fields of health, agriculture, education, home economics, and social sciences is often lacking. The importance of the interministerial cooperation and action, which is necessary to plan and to execute programs for improving levels of nutrition, is frequently not understood. . . . Much fundamental and applied research remains to be done in order to determine how traditional domestic and village level methods of food processing, which are suited to the local environment and tastes, can be developed on a commercial scale. . . .

"The application of food technology not only helps to conserve and to make foods readily available to the people, but, by rendering them easier to prepare in the home, saves valuable time, and provides other indirect but important benefits; for instance, conservation of local fuel supplies, which is often a critical factor in the selection of foodstuffs."

Among the foods that merit special attention in the developing countries are those rich in protein and suitable for the prevention and treatment of protein- and calorie-deficiency diseases. Such processed concentrates would provide protein to supplement the limited supplies of milk available and to overcome shortages of the traditional protein-short diets.

Protein-rich concentrates can be made from grains, legumes, and leaf meal, any one of which is usually available in most agricultural areas, and from fish.

But even before a developing country can use its food supplies in the production of concentrates, agricultural production and efficiency must expand beyond present levels. Until that occurs, the extraction of protein concentrates probably will occur in surplus-producing countries for shipment to other countries.

FOODS ARE PRESERVED so they may be eaten at some other place or at some other time.

Foods are processed to make them more convenient for the consumer to use and to make them into a form that is different from the starting material.

Preservation and processing, however, are so closely related that they can hardly be considered separately. What is done to preserve an item may also include processing, and vice versa. Heat sterilization by canning, for example, preserves foods, but it also makes them more convenient for future use.

Food processing today ranges from the natural processing of foods to preservation by radiation, design of foods for space flights, and synthesis of food products.

But, as J. G. Thieme, of the Food and Agriculture Organization, said at the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas, "The processing of agricultural produce in rural industries is often a 'neglected child' in the framework of development of technical assistance to the less developed areas."

His was one of only a few presentations at that meeting that acknowledged food processing as an aspect of the application of science and technology for the benefit of the less-developed areas.

Yet, even when the savannas of Africa and South America are cultivated and when the deserts of the Near East and Asia are irrigated, the cereals, fruit, vegetables, and animal products that may be produced there cannot be utilized efficiently unless they are preserved so they can be eaten far from their place of origin and long after their harvest or slaughter.

WE DISCUSS now several methods of preservation.

Natural sun drying has always been a major method. Seeds and nuts do not spoil because they have been dried to moisture concentrations low enough that microbial life cannot go on.

From ancient times, many kinds of fruit and vegetables have been gathered and spread in the sun for the same reason—to reduce their moisture concentration so they would not spoil. So also have fish and meat products been sun dried.

Sun drying is slow, except in arid areas, and many kinds of fruit and most meats and fish are sliced thin to speed drying. Where climate is not ideal for sun drying because of high humidity or precipitation, man has invented dehydration equipment to dry his foods artificially.

It is convenient here to distinguish between the foods that are naturally preserved (for instance, cereal grains and nuts) and those that are preserved by man's devising (dried fruit and vegetables, eggs, and dairy products).

Now milk and eggs are dried to powder form in spray driers, the liquid being atomized and sprayed into a hot-air stream for almost instant drying.

Tunnel and truck dehydrators with hot air delivered by fans are used extensively to dehydrate certain types of vegetables and fruit.

Modern dehydrators also include those in which wet food is placed on a belt and conveyed through equipment with temperature, humidity, and airflow carefully controlled in order to dry the products with minimum adverse change in color, flavor, or other qualities.

Some products can be reduced to small size and then blown through ducts by hot air, which both dries and conveys the product to the collecting station.

Highly complicated vacuum equipment is used to dry food products at temperatures well below room temperature even at freezing temperatures so as to reduce adverse quality changes and produce products as near as possible to the original foods.

All of these methods depend, just as does the sun drying of seeds and nuts, on a reduction of the moisture content to prevent food from spoiling.

ANCIENT MAN learned by chance that food could be preserved by certain chemicals long before his concepts of Nature allowed him to consider the existence of separate chemical compounds. Meat hung in smoke eventually took up enough of the smoke chemicals to preserve it from microbial spoilage.

Salt deposits and tidal basins were the source of another preservative chemical for man's foods. With a high salt concentration in foods, microbial growth cannot be supported.

Later, in the light of refined knowledge, benzoates, sorbic acid and its salts, and microbially produced antibiotics were found to prevent spoilage even when only a very small amount of the chemical was added.

Another type of chemical preservative has been developed. An example is the prevention of rancidity, or fat oxidation—a chemical deterioration of food—by adding antioxidant compounds.

Exclusion of oxygen by vacuum pack or by surrounding the food with a liquid material is yet another way to prevent oxidative deterioration.

In still another use of chemicals, sulfur dioxide, the principal active ingredient in the fumes of burning sulfur, is a preservative. In high concentration, sulfur dioxide will prevent microbial growth. For this purpose, sulfur candles have been burned in wine barrels and casks to sweeten them, and sulfur dioxide is added to wine musts to prevent growth of wild yeast and other microbes.

Dehydrated fruit and vegetables sprayed by or dipped in a solution of sulfur dioxide can be protected against normal chemical deterioration during storage and loss of nutrients, color, and flavor.

A special type of preservation by chemicals results from the temporary growth of desirable micro-organisms in food to produce products that develop desired qualities and components, which, in high enough concentration, preserve the food for later use.

An example is fermentation to make wine, sauerkraut, and pickles. Similarly, acidophilus and lactic bacteria form acid to curdle the protein in milk as the first step of cheese manufacture. These and other micro-organisms are then involved in curing milk curd to produce the large number of specialized cheeses known throughout the world.

Acetic acid bacteria are used to further ferment yeast-originated alcohol into acetic acid during the production of vinegar. In all these instances, some product of the microbial fermentation is eventually produced in sufficient concentration to prevent growth of undesirable organisms, and indeed, in concentration enough to curtail the growth of the producing micro-organism itself. Another major use of yeast fermentation is in making bread.

FOOD can be preserved by keeping it so cold that spoilage organisms cannot grow.

Winter climate has been a major source of refrigeration. The deep ground and cold water springs or wells lose their heat in winter and never reach peak summer temperature. Pond and lake ice have been collected and stored in sawdust and insulated structures for summertime use.

In later years, heat removal by evaporation of water has been used extensively, and is still a major source of refrigeration in the cooling towers of processing plants.

Most recently, the controlled evaporation, expansion, and compression of refrigerants has become the basis for the mechanical refrigeration systems that preserve foods by keeping them cool or frozen.

Spoilage micro-organisms can be destroyed by heat. Heat sterilization of foods in containers that do not allow reinfection with spoilage organisms is one of the few preservation methods discovered by modern man, but it has become an important one.

The pasteurization procedures used for milk and other beverages make it possible to control the degree of contamination with micro-organisms and cause the destruction of certain disease-causing organisms.

Cooking and baking food imparts a high degree of preservation to many products by reducing chance contamination. Recontamination of heat preserved or pasteurized foods can cause food to spoil. Heat-sterilized foods are preserved only as they may be protected from recontamination.

Heat is also uscd to control certain chemical changes that are not related to spoilage micro-organisms. For example, when vegetables are preserved by freezing or dehydrating, they are first blanched (scalded) with boiling water or steam to destroy the biochemical compounds that cause certain flavor and color deteriorations in the preserved foods.

Some important foods are preserved by separating them in pure forms that will not spoil.

Sugar is obtained from sugarbeets and sugarcane. From sliced beets, sugar is diffused with hot water. Cane is crushed between rollers. The diffusate or the pressed juice is purified by chemical reactions and filtration and concentrated by boiling. Pure sugar is crystallized by cooling the supersaturated concentrate and separated by centrifugal filters from the remaining molasses. Partly refined sugar concentrate from cane is often exported for final refinement in the consuming country.

Vegetable and essential oils are also separated from seeds and other parts of plants in a pure form that is useful in food and industrial products. Oil from seeds of cotton, soybeans, peanuts, or other plants is recovered by pressing or by solvent extraction and clarified and purified by filtration, tempering, and so forth.

Essential oils are generally steam distilled from seeds, pods, stems, leaves, wood chips, blossoms, and so on. They are purified and stabilized by various treatments in a form useful to the consumers and preserved so they can be shipped.

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