A FEW of the 5 thousand-odd food items sold in a modern supermarket are fresh, but most of them are processed—canned, waxed, dried, frozen, bottled, pickled, packaged, wrapped, baked, changed in one way or another.

Stabilization of foods, which keeps them from spoiling, is a main purpose of processing.

Micro-organisms are the first thing we think of in connection with deterioration of food. Yeasts and molds work primarily on acid fruits and cause them to become soured, yeasty, or moldy. Bacteria, the main troublemakers in most other foods, cause changes all the way from lower quality to putrefaction.

Other chemical changes go on all the time—before, during, and after processing and when there is no processing. Enzymes, present in every living cell, speed up some of the chemical reactions.

When food is canned, heat destroys the micro-organisms that cause food to spoil. Hermetic sealing of the cans prevents later contamination.

Preservation by dehydrating and freezing deprives the organisms of some condition they need for growth—water or warmth. Both processes destroy some organisms but not all. The organisms grow again if water or warmth is restored.

Some common ways to slow down chemical changes are to keep foods cool, protect them from light, add chemicals that interfere with reactions, and minimize contact of the food with air—by driving the air off with heat, removing it with vacuum, or replacing the air of the package with an inert gas, such as nitrogen, which does not combine with foods.

To cut down the loss of vitamins and minerals, a processor has to keep in mind that all B vitamins, vitamin C, and some of the minerals dissolve in water and may be thrown away in the water. Vitamins A and D dissolve in fat—for example, in the oil on canned fish. Contact with air is damaging to vitamins A, C, and D. Vitamin B₁ is destroyed by heat in nonacid foods, even in the absence of air. Light is bad for vitamin B₂ and perhaps also for A and C. All these losses occur faster in warm foods than in cold foods.

The first limitation on the quality of a processed food is the raw material from which it was made.

If a turkey to be frozen has eaten...
food that produces the kind of fat that becomes rancid rapidly, or if the peas are starchy, the fruit is green, the variety of strawberries is low in flavor and color, the final product will be no better.

Just as not all apples are good for eating and not all potatoes are good for baking, not all types of raw material are good for processing. Fresh-market potatoes are produced in nearly all States, but a few varieties grown only in special areas are best for drying and freezing.

Different processes for the same food may have different requirements.

Mealy potatoes with a low water content are best for dried mashed potatoes. The waxy type is best for canning. These two types can be separated with salt brines, because the mealy potatoes sink in it and the others float.

Economic considerations sometimes dictate the use of varieties other than those known to be best. Less desirable varieties may be included in the total pack in a year in order to extend the processing season beyond the short time the best variety is available.

Having decided what raw material to buy, the processor must next make sure it arrives at the plant in good condition—as quickly and as cool as possible.

Fish and shellfish used to be subject to long delays, but the situation has improved. Much fish is packed heavily with crushed ice immediately after it is caught. Large quantities are frozen on ships and are thawed and eviscerated in plants on shore. Some is completely processed—canned or frozen—aboard ship. These procedures help preserve flavor and quality.

Rapid cooling and refrigeration of milk, eggs, meat, and poultry are necessary whether they are used in fresh form or in processing.

Asparagus, sweet corn, peas, and lima beans are the most perishable of the processed vegetables. They rapidly lose flavor, sweetness, general excellence, and vitamins B₂ and C unless they are processed promptly or kept cool.

Peas present a special problem because some are vined (threshed from vines and pods) at stations some distance from the plant. An objectionable flavor develops quickly in bruised, warm peas. The trend has been to vine at the plant or to water-cool the peas at the vining stations.

The first procedures in the processing plant are cleaning, sorting, grading, and preparing the foods as for table use—eviscerating the poultry, peeling the fruit, straining the milk, and so on.

The foods must be clean. An inspector can easily see whether a plant is clean. Standards of cleanliness usually are high.

Sorting and grading have a good deal to do with the uniformity of packs. The extent to which a processor can afford to separate material into sublots adapted to different uses depends largely on the diversity of his line of products. Some persons believe that separations based on appearance have been carried too far and those on flavor not far enough.

Many foods are transported in the plant in a trough—a flume—of water. Some of the flavoring constituents and vitamin C, the B vitamins, and minerals are lost thereby. Some processors have replaced flumes with conveyor belts.

After they are prepared for table use, most foods receive some kind of treatment, such as blanching, pasteurizing, concentrating, or sulfiting. (Each of these terms we explain later.)

Many liquid products—milk, cream, eggs, fruit juices—are pasteurized. Pasteurization is mild heating, which destroys all or most micro-organisms, depending on the product. It also inactivates enzymes and so helps in retention of flavor and color of the foods. Pasteurization of orange juice that is to be concentrated and frozen reduces the amount of separation into pulp and clear layers during storage but tends to take away the fresh flavor.
Batch pasteurization, which involves heating liquids at about 165° F. for 15 or 30 minutes, is giving way to continuous high-temperature, short-time procedures, in which the fluid is rapidly heated and then cooled as it flows through a series of coiled tubes. It may take only a fraction of a second and gives better flavor and color.

Most vegetables and some fruits are blanched. Blanching consists of cooking pieces of food for a short time in water or steam. Small pieces, such as peas, are cooked for about a minute at the boiling temperature or for a slightly longer time at lower temperatures. Larger pieces are cooked longer. The purpose of blanching is to inactivate enzymes and thus enhance the retention of color and flavor during storage.

Blanching procedures are not standardized. Some processors have a leaching loss of 5 to 10 percent of each water-soluble vitamin or other constituent. Others have losses of 40 to 50 percent—or even higher with the same food.

Losses are larger in water blanching than in steam blanching and larger with long-low temperature treatment than with quick-high temperature treatment. Industry has changed largely to quick-high temperature blanching for frozen green beans, and the color of the product has been greatly improved.

Considerable research has been conducted to develop electronic blanching, which would avoid losses through leaching, but a satisfactory procedure had not been worked out in 1959.

Some dehydrated and frozen fruits and vegetables are sulfited instead of blanched. A few are both blanched and sulfited. Sulfiting consists of exposing the food to sulfur dioxide gas or dipping the food in a liquid containing a similar substance. Either way, the sulfite protects color and flavor of the food by combining with the enzymes and thus inhibiting them. The chemical may disappear gradually during storage at the temperatures used for dehydrated foods. The protection then is lost. Sulfite aids in the retention of vitamin C, but it destroys vitamin B1. Too much sulfite gives a flavor that most persons consider objectionable.

Because we want berries, peaches, apricots, and cherries for dessert to taste as uncooked as possible, they are not blanched, but are covered with sugar sirup, which shuts out air and gives them some protection from oxidation.

Vitamin C sometimes is added to the sirup for apricots, peaches, and cherries to increase their stability. Oxygen combines with the added vitamin instead of with the fruit constituents. The vitamin may be used up during storage.

Soups, milk, fruit juice, and other liquids sometimes are partly concentrated before they are canned and frozen in order to reduce the amount of material to be packaged, shipped, and stored. The water is removed at a reduced temperature by means of a vacuum. There is little impairment of quality or nutritive value in this step.

The recovery of fruit essence is a special application of concentrating. It saves the components of flavor. The flavorful vapors that boil off during the early cooking of jelly and other fruit products are collected, condensed, and concentrated. The essence may be added to jelly in the final cooking stage, to fruit beverages and juices, fruit-flavored ice creams, and other fruit products.

Irradiation is a potential processing method for foods. Although no irradiated food was on the market in 1958—in fact, the law did not permit it—millions of dollars have been spent on research on irradiation.

Just as X-rays can be used to destroy cancer cells in the human body, gamma rays or high-speed electrons can be used to kill micro-organisms and insects in foods. Irradiation does not make the foods radioactive.

The first patent related to irradiated foods was taken out in France in 1930 by Otto Wüst, but extensive research
did not start until 1947. Hundreds of papers have been published since then by universities, Government agencies, and private industries.

Small exposures to radiation (less than 100 thousand rads) have been used experimentally to prevent sprouting of potatoes, destroy insects in flour and spices, and delay the ripening of fruit. Such low levels usually have little or no effect on the flavor or color of foods. Radiation dosages in foods are now almost always expressed in rads. The rad represents 100 ergs of energy per gram of the irradiated material.

In the range of 100 thousand to 1 million rads, a medium level, a sort of “pasteurization” takes place—that is, nearly all the micro-organisms are destroyed, but the product is not made completely sterile. After exposure in this range, meats, fish, and certain other foods can be kept longer under refrigeration, and the shelf life of fruits and vegetables is extended.

Many products suffer a serious loss of quality at 1 million rads, but a lower level can often be found which will improve keeping quality without substantial changes in flavor, color, or texture. Irradiation at these levels may be used in conjunction with other methods of preservation, such as canning, freezing, or dehydrating.

Large exposure to radiation (a few million rads) sterilizes foods so that they can be stored like canned foods when they are suitably packaged. Such levels, however, often cause serious off-flavor, especially in meat and fat, and marked softening of vegetables.

Research is being continued to try to achieve stability without damaging foods and to reduce the rather high cost of the method.

Research results as to the safety of continued eating of irradiated foods are encouraging, but safety had not been proved in 1959.

Many chemicals are added to foods. They include coloring agents; flavoring materials; mold inhibitors, such as the propionates in bread; antioxidants, which delay development of one kind of fat rancidity; emulsifiers, such as the ones used to prevent separation of french dressing; bleaching agents, as for flour; thickening agents; and substances to prevent caking of powders. They are called additives.

Relatively few additives were used in 1938. The Federal Food, Drug, and Cosmetic Act passed that year protected the consumer at the time. But technologists learned soon thereafter that additives can help food processing in many ways. Hundreds of chemicals not used in 1938 and many not then known came into use. People became concerned about the safety of some of the substances. After much controversy and study, the Congress passed in 1958 the Federal Food, Drug, and Cosmetic Act, as amended.

Let us look at these developments in more detail.

The 1938 law did not provide for advance clearance of safety of food additives. It left it up to the Food and Drug Administration to discover their use in foods already on the grocers’ shelves and to make tests to prove them “poisonous or deleterious” to the satisfaction of the court in order to remove them from the market.

So many additives came into use that it was impossible for the Food and Drug Administration to keep up. Even those for which testing could be undertaken could stay on the market while the lengthy tests (usually 2 years of feeding tests with animals) were being conducted. A congressional committee investigated chemicals in foods and reported that only 428 of the 704 chemicals used in foods were definitely known to be safe.

Many sponsors of new food additives made the necessary tests and checked with the Food and Drug Administration before using the additives. But some did not—and the law did not require it.

The 1958 amendment to the food and drug law provides that industry must prove the safety of chemicals used
Variety in Foods, from Processing
in the processing of foods before the chemicals can be sold for use in foods. The promoter of the additive has to test it for safety on animals and submit the test results to the Food and Drug Administration. If the evidence seems satisfactory under proper conditions of use, the Food and Drug Administration issues a regulation specifying the amount that may be used, the foods in which it may be used, and any other necessary conditions of use.

If the safety of the additive is not established, the petition is denied. A promoter who is not satisfied with the decision can ask for a public hearing and court review.

We all know the advantages and limitations of canned foods. They are convenient to use, reasonably stable during storage at room temperature, and as safe as we can expect any food to be. No case of illness traceable to microbial spoilage of commercially canned foods has been reported since the late 1920's.

The color, flavor, and texture of many canned foods are different (because of the long cooking required to make them safe) from those of home-cooked fresh foods. Some people like the canned foods and simply think of them as different from the fresh foods.

Canners worked for a long time to develop a safe heat process that would not overcook foods. Now they have one that keeps the good quality of many products. It involves heating the food for only a few seconds—at most, a few minutes—at about 285° F. These times and temperatures are approximate. Many factors determine the exact conditions for a particular food.

The new process is called high-temperature, short-time, or high-short processing. Its principle is that destruction of bacteria increases about tenfold for each 18 degrees of rise in processing temperature, while the chemical reactions responsible for the deterioration of the product are only doubled. Thus the food is made safe without being overcooked.

Aseptic canning uses these principles. The food is processed under conditions that provide rapid heat penetration. Then it is filled into cans and sealed in an aseptic chamber to avoid contamination during these operations.

Products prepared by the new process in 1959 included several milk, fruit juice, and creamed-soup goods. Many other foods have been successfully prepared experimentally—baby foods, corn, peas, diced vegetables, tomato juice, and several kinds of fruit. Very likely almost any liquid, puree, or small-piece food can be canned successfully by the new process. Foods that are packed in chunks, such as meat and fish, will have to wait for developments in other processes, such as high frequency electronic heating.

Another new way to reduce the heat damage in canning involves adding substances that increase the killing effect of heat on bacterial spores (the form in which bacteria are hardest to kill). The substances make it possible to destroy the bacteria with less heat than the usual canning process requires.

Of the 650 substances tested up to 1958, 26 speeded up the killing of spores, but some of them are unsuitable for use with food because of odor or toxicity. Among the most promising are two antibiotics, subtilin and nisin. Nisin occurs naturally in some types of cheese. Other effective substances are propylene oxide (which is now used in dried fruit), diepoxybutane, dodecylguanidine, and hydrogen peroxide.

Before any of them can be added to commercially canned food, it must be demonstrated that they kill the spores that have been put in experimentally canned food. Some canning tests have given favorable results. It must be proved by feeding tests with animals that any substance proposed for commercial application is not toxic under prolonged use. The tests may take 2 years.

Dehydrated foods usually are economical. Most of them are relatively
easy to prepare. Their small weight and volume make them convenient to store. They are well adapted to use whenever transportation is a problem.

Much has been done to improve the quality of dehydrated food. Among the things that have led to improvement are the use of raw material that is better adapted to the requirements of dehydration; new processing technology; more careful application of known processing procedures; less dependence on sulfiting for vegetables; improved equipment, especially dryers; lower moisture content in the finished product; and packaging with inert gas.

The aim in dehydrating is to remove most of the water from food—sometimes 99 percent of it—without damaging the product. Heat damage causes a brown color, scorched flavor, and changes in texture. The first portion of water is removed rapidly, with little impairment of quality. Most of the damage occurs when the food is almost dry and water is removed slowly.

Better equipment for spray drying, which gives less heat damage during drying, has improved the quality of dried eggs. A treatment applied to the egg mix before drying also has helped. An important cause of deterioration of dried eggs in storage is that the natural sugar and a protein constituent of the egg combine to make a substance that is objectionable. The new treatment adds substances that change the sugar so it cannot combine with the protein.

Better spray dryers also have improved the drying of milk. The quick rehydrating quality of the new skim milk powder, however, is due to a second drying step, which gives the particles a fluffy, porous, spongelike structure. It took 30 years of research to achieve the powdered—instant—skim milk that came on the market in 1954.

Many piece foods are dried on trays in a forced-draft tunnel, where air circulates past them. Often part of the material is damaged by heat before the rest is dry enough to store.

Several new dryers provide more uniform and better results than the one we described. With the fluidized-bed dryer, enough hot air is blown into granular-type food so that it flows like a liquid and is kept in suspension in air throughout the drying time. This equipment is used commercially in the final drying stage for dried mashed potatoes in the form called granules.

The new belt-trough continuous dryer tumbles the food on the belt to give uniform drying. Another dryer gets uniform heating by turning the food from one conveyor belt to another at intervals.

In prospect is dehydration under high vacuum—thus at very low drying temperature and in the absence of air. The drying step can then be done with little or no loss in the overall quality of the original, unprocessed product. High-vacuum drying also makes it possible to remove practically all of the water from foods so that, suitably packaged, they store well.

The high-vacuum process works well for the dehydration of fruit juices, which are difficult to handle by conventional drying procedures because their high sugar content causes caking and sticking. Besides, some fruit juices, especially citrus juice, develop off-flavors quickly in the presence of air.

Considerable quantities of orange and grapefruit juice powders produced by the method were sold in 1958. It was expected that blended orange-grapefruit juice powder and tomato juice powder would be available before long. The latter can be reconstituted to single-strength juice or (with less water) to a puree or paste. The tomato powder can be used in dry mixes for tomato aspic, spaghetti sauce, and similar products.

Vacuum can be used with both shelf and continuous-belt drying of beverages, eggs, and fruit and vegetables in piece or juice form. The process is rather expensive, however, and was not widely used commercially in 1959.

Freeze drying, another low-temperature drying method, has produced excellent products, especially meats, which are hard to dry satisfactorily.
In-package desiccation sometimes is used to remove the last small amount of water from dehydrated foods. A small envelope containing a chemical (activated lime) is put into the final package. It absorbs water from the food during storage. The procedure avoids the damage to quality that occurs in the late stage of usual dehydration, but it raises the cost a little.

Many dehydrated foods—including many experimental packs produced by the newest techniques—were used in the ration for Antarctic explorers during the International Geophysical Year. A typical meal, weighing a pound, consisted of two dehydrated beef steaks, dehydrated onions, mashed potatoes, green beans, crackers, canned butter, canned fruit cake, and dried, instant chocolate milk.

Cereals we may not think of as dried foods, but their stability is due largely to their dryness. The cereal grains are dried partly or completely in the field.

The first thing a consumer wants to know about a cereal food is whether the whole seed or only the endosperm—the inner portions of the kernel—was used in it. The outer bran layer of the seed and the oily germ contain important nutrients, but they may be discarded because they do not keep well or because people do not like them.

The miller of white flour reduces the endosperm part of the seed to the particle size of flour, blends different lots to get the properties he wants for particular uses, and adds chemicals to speed up the normal bleaching and maturing of the flour.

A new procedure in milling involves separating batches of flour into smaller lots, each of which is adapted to a particular use. Streams of air at different speeds separate the heavy particles from the light ones.

Bakers and manufacturers of dry bakery mixes often buy flour that meets a specified performance standard in a given formula. Thus bakery products—those the homemaker buys and those she makes—are likely to be better and more uniform.

Cereal foods are enriched to compensate for the nutrients lost in processing to make them stable. A finely powdered mixture of vitamin B₁, niacin, iron, and vitamin B₂ is added to wheat flour during milling. Standards of enrichment have been established for a number of staple foods.

The National Academy of Sciences-National Research Council has endorsed the enrichment of flour, bread, cornmeal, and white rice. The other chemicals used in flour, as well as those in bread, have been evaluated, and specified amounts of each have been approved by the Food and Drug Administration.

The protein quality of breakfast cereals—both the prepared cereals and the ones you cook—is improved in two ways. Sometimes several cereals, such as wheat, oats, barley, and even flaxseed, are combined to provide a better balance of proteins. Sometimes proteins from other foods—wheat gluten, soybean protein, or casein from milk—are added.

A growing proportion of cereals reaches the consumer as ready-to-serve breakfast foods—flaked, shredded, granular, puffed, and toasted cereals. Some have sugar coating. The consumer usually pays more for the prepared cereals than for equal nutrients obtained from cereals she cooks herself.

Cereals and foods made from cereals account for more than 20 percent of our food calories, and they furnish nearly all of our vitamin B₁.

We buy much white flour in the form of dry bakery mixes, which one can prepare for the oven in a few minutes. They are scientifically prepared and yield uniform quality time after time when they are finished at home. There are mixes for angel-cake, butter and fruit cakes, cookies, piecrust, rolls, muffins, and others.
The mixes are prepared in the plant primarily by mixing automatically the weighed dry ingredients together by hoppers, feeders, and conveyors. Then oil is incorporated into it by spraying it on the dry ingredients or by cutting fat into the mix by machines.

A big problem has been the development of rancidity in the mixes. It gives an objectionable flavor and impairs baking quality. Another problem concerns the leavening agents. Sometimes they react before baking time and cause the finished product to have poor volume. Both difficulties have been lessened by drying the flour to a water content of 6 to 7 percent instead of the usual 13 or 14 percent. A strong taste of baking powder in the baked product means the processor has been apprehensive about having enough leavening agent left by baking time.

Other combinations of several dried ingredients in one package are the dried soups. Each ingredient is dried separately. The beef extract may be dried on a drum dryer, the vegetables in a belt-trough dryer, and noodles on trays in a tunnel. Finally the dried spices and seasonings are mixed with the other ingredients, and the complete mix is redried.

The finished soup is no better than its ingredients. The manufacturers are looking always for better ingredients and a more convenient product—soup that rehydrates instantly with boiling water, for instance.

Production of frozen foods increased from 275 million pounds of edible weight in 1932 to 7,329 million pounds in 1955. Ice cream, cream, eggs, poultry, and wholesale cuts of meat are not included in the figures. When they are added, the production was about 10 billion pounds in 1955.

Flavor, color, and nutritive value of most foods change little or not at all during the freezing step itself by present commercial procedures. If a frozen food is poor in these respects, we usually find that poor raw material was used, or it was handled poorly prior to freezing, or the frozen food was stored too long at too high a temperature.

It is possible to freeze so slowly that flavor, color, and nutritive value are impaired, but that is not a common cause of trouble.

The texture of frozen food is something else. The texture of several is changed by the freezing itself. Raw salad vegetables, such as lettuce and tomatoes, become too limp for use. Most fruit is softened. Raw egg yolk—but not egg white—jells and does not regain fluidity after thawing unless salt or sugar or glycerine is added. These additives limit the later use of the frozen eggs.

Packages for frozen foods have undergone many changes. Many frozen foods would retain high quality longer if they were packaged in hermetic containers—in the absence of air—instead of in paperboard or other non-hermetic materials. Only a few foods are so packaged, mainly because hermetic containers cost more.

Poultry is especially vulnerable to drying out, which causes discolored skin. To minimize this effect, birds may be wrapped in moisture-impermeable materials, such as polyethylene.

Dehydrofreezing of fruits and vegetables aims to combine the best features of both drying and freezing. Dehydrated fruits and vegetables offer the economies of greatly reduced weight and volume, but quality may be impaired in the late stages of drying. Freezing has advantages, but costs of storage and transportation are relatively high.

Dehydrofreezing consists of drying the fruit or vegetable to about 50 percent of its original weight and volume—but not to the stage where quality impairment occurs—and then freezing the food to preserve it.

The quality of dehydrofrozen fruit and vegetables is equal to that of the frozen products, but they cost less (be-
cause of smaller weight and bulk) to package, freeze, store, and ship.

The foods that have been satisfactorily dehydrofrozen include peas, carrots, potatoes, apricots, cherries, boysenberries, and apples. The homemaker buys dehydrofrozen foods now only in remanufactured foods—vegetables in soup, for example, and fruits in bakery pies.

FROZEN PRECOOKED foods have developed mostly since the late 1940’s.

Today almost a billion pounds of 200 kinds of these foods are sold.

They include almost every food prepared in the home—soups, meat, poultry, fish dishes, nationality foods, bakery products, desserts, and complete dinners.

A number of frozen precooked foods can be made in almost the same way as the unfrozen foods. They include most breads, rolls, cakes, pies, other pastries, and waffles. They have essentially the same quality after relatively long storage as the product before freezing. They require wrappings that keep the food surfaces from being soaked with the moisture that condenses on the package during thawing.

A good many products are relatively unstable. Sometimes the storage life can be lengthened by adding sauces and gravies, which displace the air of the package. The absence of air retards the change in flavor that oxidation would cause—a common cause of warmed-over and other undesirable flavors in precooked dishes.

The sauces that contain egg or the usual starchy thickeners—gravies, white sauces, puddings, and fillings for cream puffs—separate or curdle on freezing. Curdling can be overcome commercially by the use of special thickening agents and stabilizers that are not readily available to homemakers.

As FROZEN foods are not sterile, they must be handled as perishables from the time they are processed until they are eaten.

Many micro-organisms are destroyed during processing, but some almost always remain in the food. They begin to multiply when the food thaws. If the food is held too long after defrosting, off-odors and off-flavors develop, consistency and appearance change, and finally the food spoils completely. Some frozen foods spoil faster than similar fresh foods, and so they should be eaten reasonably soon after they are defrosted.

The bacteriologist carries out two kinds of tests on frozen foods—tests to determine the number of organisms and tests to determine whether the food is likely to contain the kind of organisms that might make people ill.

Frozen foods produced under highly sanitary conditions contain only a small number of bacteria. They are less likely than foods with a high bacterial count to contain food-poisoning or disease-producing bacteria. Furthermore, foods prepared under conditions that give low bacterial count also are likely to be more nutritious and, in general, higher in quality.

Although we want frozen foods of low total count of bacteria, we are more concerned about the possible presence of even a few bacteria of the kind that could cause illness.

The possible sources of disease-producing bacteria are the soil on which foods grow, people who handle foods in processing plants, and, in the case of animals, the foods themselves.

Most specialists believe that the frozen foods we cook in the same way as fresh foods are as safe as similar fresh foods. Examples of such foods are frozen vegetables and frozen raw meats. Both are cooked—not just warmed—before they are eaten.

The situation with frozen precooked foods is quite different. They present several special problems and require extra precautions in the processing plant and at all stages until the food is eaten.

Precooked foods offer more chances for contamination before freezing than do the simpler frozen foods. Most of them contain several ingredients, each
of which may be contaminated. Operations often are carried out by hand, such as hand boning of chicken.

Some of the preparations take time, and bacteria may increase during delays—especially when various foods for one package are cooked separately. The gravy for a plate dinner might be ready before the french-fried potatoes, for example.

Another reason some precooked foods require special precautions is that they are not cooked so long at serving time as the similar home-prepared foods. Many of the frozen precooked foods are not really cooked in the home. They are just warmed. We need therefore to keep such foods frozen until we are ready to cook them so that any bacteria in them cannot multiply.

There have been few authenticated cases of illness traceable to frozen foods. But new processors and new products enter the field all the time, and great care must be taken to insure the production of wholesome products.

The food industries that produce and distribute frozen foods, as well as homemakers and regulatory agencies, have responsibilities for the sanitary conditions of foods. Early in 1956 representatives of industry and food and drug officials started a large project of great interest. The purpose is to establish sanitary codes for frozen foods from producing plant through warehousing and transportation to handling at the retail level. The code, a voluntary one, would be used as a guide by the various States and municipal food and drug enforcement agencies. The first draft of the code for frozen precooked foods was expected to be ready in 1959.

When we consider all the processes a food goes through, we realize how hard it is to produce a high-quality food, even with all our scientific controls. Quality can be lost at almost every step in processing.

Most processed foods therefore are not fully equal to strictly farm-fresh foods or freshly caught fish or home-baked cake. But when we cannot get the farm-fresh foods and do not have time to bake the cake we are glad to have the processed foods.

Before considering the effects of the specific processes on costs of foods, let us look at total costs of food.

Americans spent about 20 billion dollars for food products in 1941. They spent nearly 70 billion dollars in 1958. They spent 25 percent of their cash income on foods in 1958. For the same kinds and quantities of food that consumers bought in 1935-1939, they would have spent only 16 percent of their income in 1958. It is obvious that our food does cost more. Many factors contribute to this increase besides the additional costs that might be attributed to processing. Consumption of more expensive food items, higher marketing margins, and more food eaten in restaurants are other factors.

The Census of Manufactures gives some indication of the total bill for processing. The value added by manufacturing in food and kindred products amounted to 3.5 billion dollars in 1939. The comparable figure in 1954 was 13.5 billion dollars.

The figure for 1939, adjusted to 1954 prices and for increased population, becomes 9.5 billion dollars. This, then, is evidence that our homemakers are now paying 4 billion dollars a year more than they did in 1939 for the convenience of having some of the work of food preparation transferred to the factory.

This figure, however, does not represent the net cost for this transfer of functions. Having foods in prepared form instead of raw form necessarily affects the costs of transportation and distribution. In some instances, these costs are less; in others, they are more, mainly because of such factors as weight, bulk, and type of storage required. While the total food processing bill has increased on a comparable basis, processing has lowered costs in many instances.

The first factor that affects proc-
**Effect of Processing on Cost of Food**

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<th>COST INCREASE</th>
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processing costs is the cost of the raw material.

Factory purchases of raw material often are made under contracts with farmers. Prices so agreed on usually are lower than prices farmers get from fresh-market sales, because farmers may prefer the security of a fixed price contract over the insecurity of possibly higher but greatly variable prices received from the fresh market. Thus, asparagus for processing in 1957 averaged 168 dollars a ton in California; fresh-market asparagus averaged 272 dollars.

Another factor that helps reduce costs associated with processing is that factories can use grades of raw material that would not be suitable for fresh-market sales. The factories can use poorly colored apples, misshapen potatoes, jumbo sweetpotatoes, small oranges, and eggs having discolored shells, all of which are available at much lower prices. These imperfections are meaningless in some processes, because the raw material is peeled and cut into pieces, or made into juice, or handled in some such way.

Processing converts perishable raw material to a stable form, of which very little is lost before it reaches the consumer. The shipment of raw material in fresh form and the subsequent distribution often result in considerable wastage and spoilage. Perhaps this loss is most obvious in retail stores, where often much raw produce is discarded. One source estimates this loss to total 125 million dollars a year for fresh eggs alone.

Elimination of waste parts of the material in processing offers substantial savings in the costs of packaging, storing, and transporting food products from farm to market. The pod, representing more than half the weight of green peas and lima beans, is eliminated in processed products. Cut sweet corn is only one-third the weight of the corn in the husk. Thirty percent of the weight of the wheat kernel is removed in the production of flour. Canned orange juice represents about 60 percent of the weight of fresh oranges.

A part of these savings in weight is offset if brine, sirup, or sugar is added as in canning. A No. 2½ can of peaches may contain 11 or 12 ounces of sirup and 18 ounces of peach halves. The total weight of the canned product shipped thus is likely to be greater than the weight of fresh peaches used in making the pack.
Food Costs in Dollars and Hours
Expenditures per day for a family of four

Processing makes savings possible by complete utilization of a crop or animal. Most meats are sold in fresh form, but complete utilization of the carcass is possible only because parts not sold fresh are processed into canned-meat products and byproducts. Peel from citrus-fruit processes is made into feed products. Processing of milk makes possible a wide range of products, each utilizing a fraction of the original—for example, butter, cheese, skim milk, milk powders, and whey. Apples that are rejected from fresh-market packinghouses may be made into juice; the peel may be processed for pectin; and the remaining cake made into cattle feed.

Processing can also, in effect, increase costs of raw materials and produce a product for a special market. By selecting a high-quality part of the original material, a processor can upgrade the product considerably. Perfect peach halves, packed in heavy syrup, can be sold at premium prices. Other examples of this upgrading include artichoke hearts, tiny peas (petits pois), and white flour.

Recognition of additional costs involved in handling and storing unnecessary weight prompts research into ways of reducing these costs.

We now have canned vacuum-packed cut corn containing only a small amount of liquid and canned packs of apples and apricots containing no added liquid at all. Concentrated products eliminate even more weight. A can of frozen orange juice concentrate represents the equivalent of four cans of juice. Dehydrofreezing reduces the weight and bulk of fruits and vegetables by 50 percent before freezing. Condensed canned soups represent a 50-percent reduction in weight and bulk.

These savings make possible sizable reductions in the cost of packaging, storing, and shipping. Dehydrofrozen peas packed for restaurants could save the user more than 2 cents a pound, compared with conventional frozen peas. Frozen orange juice concentrate generally sells at prices that are lower than those for equivalent amounts of canned juice.

A complete list of technological advances would be impossible to make, but we mention some notable ones.

Developments that have made important reductions in costs are those concerned with materials handling and with continuous processing.

One materials handling method, called hydroconveying, carries the product in a stream of water, either in open troughs or flumes or in pipes. The canning and freezing industries widely use hydroconveying for moving such items as fruit and vegetables. Vegetables of small uniform size, such
as green peas, lima beans, and cut corn, often are conveyed in water through pipes. Specially designed water pumps are used to elevate the mixture to higher levels.

Continuous or excessive contact with water often lowers the quality of the product mainly because soluble solid components leach into the water. Products having exposed surfaces resulting from peeling or cutting of the material are especially susceptible to leaching losses. Hydroconveying does have some advantages, however, which may offset somewhat its disadvantages. It results in transport of material at a minimum of time and labor cost. It reduces desiccation or drying of the product. It partly cools the product, an advantage in the freezing process.

Bulk transport also leads to savings. The material is hauled in large containers, trucks, and tanks without being packaged in small units. A tank car, an example of a bulk transporter, can carry dry or liquid materials. Sugar in liquid form, which many factories use, can be delivered in tank cars or trucks and transported within the plant through a pumping system. More and more milk is handled right from the farm in bulk in tank cars or trucks.

Bulk transport also is used for grain, peanuts, and soybeans. Many fruits and vegetables for processing are carried in bulk. Large containers, called tote boxes, each carrying as much as a ton or more, are used for hauling raw material to the plant. Within processing plants, large bins are used to carry dry ingredients, such as flour. Lift trucks are finding an ever-increasing application. These efficient machines can lift a tote box or a pallet load of cases or boxes weighing several tons to heights above 20 feet and can carry the loads quickly throughout the plants and loading yards.

Pneumatic conveying, or carrying materials in a stream of air, is finding increasing application in handling products in powdered, ground, or flaked form. Pneumatic conveyors carry flour, milk powder, sugar, beans, cocoa, coffee, peanuts, malt, and rice. Powerful blowers force air at high speed through a duct into which the product is fed. The duct may run from one machine or storage container to another within a building, or it may run many hundreds of feet between buildings. The product is separated from the air in a collector, which permits the flow of air greatly to decrease, dropping the product at the bottom while the air slowly rises to an exhaust vent.

These large-scale and continuous transport methods greatly reduce handling costs. Older methods use considerable hand labor. The result is a lower cost per unit of finished product. One man can now move hundreds of tons of product in a large, well-organized processing plant.

Factory preparation of food offers cost advantages to be gained from the large-scale and scientific processing. Newer types of cookers in canneries are continuous. The batch type was used previously. Even butter, cheese, and ice cream can now be made in continuous processes. Continuous diffusers give an improved extraction of sugar from beets and drastically reduce labor costs. Continuous ovens, automatic bread depanners, and band slicers that can slice 50 to 60 loaves a minute have become common.

A piece of equipment usually is classified as continuous if the items it handles are fed to it and discharged without interrupting its operation, with little if any requirement for labor. An oven in the home is a good example of a batch machine. It cooks one loaf, cake, pie, or load at a time. A continuous oven may consist of a very long chamber through which a belt moves continuously. The burners within the chamber are so located and regulated that items of bakery goods can be fed continuously into one end and emerge completely cooked.

Citrus fruits are squeezed for juice automatically. Peaches, pears, and
Apricots are automatically filled into cans in contrast to costly hand filling previously used. Exhaust boxes have given way to vacuum closing, which saves processing time. High-vacuum, low-temperature, continuous evaporators are used extensively in producing citrus juice concentrates, tomato pastes, and other concentrates.

New continuous types of dehydrators find increasing application. The belt-trough dryer dries fruit and vegetables uniformly with a minimum of labor. The investment cost per unit of drying capacity is low.

All of these advances have brought about important reductions in processing costs, despite large investments generally required to set up factories. Low unit costs are made possible by the large volumes of food that are efficiently put through the plants.

Costs of packages for processed foods vary greatly. Sometimes the package may cost as much as the food itself. Hermetic containers, such as are necessary for canned products, are relatively expensive. So are containers for liquids or products that become liquid.

The container cost is reduced if a product can be held so that it does not need a hermetic seal. Thus the paperboard package for frozen peas and the cellophane bag for dried fruits are less costly than the tin can for these canned foods. Some of the new materials, such as foil and a plastic film laminated together, are nearly hermetic and intermediate in price between tin cans and simple films. Aerosol, or bomb-type, packages are expensive.

Packaging costs can be reduced by reducing the amount of water included in or with the food to be packaged. Dehydrated mashed potatoes represent about one-fifth the weight of peeled raw potatoes. Orange concentrate represents one-fourth of the weight of the juice.

Portion control has been receiving much attention. A package of meat may contain four equal-sized servings. A package of dried mashed potatoes may contain two envelopes, each holding enough material for serving four persons. Individual servings of jam and chocolate-beverage powder are other examples. Portion packaging increases container costs, but it may avoid waste in the kitchen.

Frozen, canned, and dehydrated foods have advantages and disadvantages as to costs.

As a group, dehydrated foods generally offer the greatest cost savings to the consumer. They are greatly reduced in bulk and weight. They do not require costly storage temperatures. Packaging requirements generally are not critical. Dehydrated foods are not always the least costly, however. Dehydrated foods become more expensive if vacuum drying is necessary and if the output is small in relation to size and cost of equipment. Two examples: Ordinary dried apples are usually the lowest in cost of all processed apples. A new product, vacuum-dried orange juice powder, however, is likely to be quite costly, even more than the equivalent quantity of frozen or canned juice. Not only must dehydration be carried out under a high vacuum, a relatively costly process, but the product must be hermetically sealed to prevent a gain in moisture content.

Canned and frozen foods offer advantages and disadvantages in costs. The higher cost of the tin can is a disadvantage. The higher cost of freezing temperatures for transportation and storage of frozen foods also is a disadvantage. The relative importance of these factors differs with each product and situation. We might say that frozen peas should usually be sold at a lower price than the equivalent canned, but that canned condensed soups not requiring refrigeration should be cheaper than frozen soups of the same degree of concentration, because both are packaged in tins.

One question that naturally arises in any discussion of changes in processing costs is whether the increases in costs and the savings have been passed on to the consumer. The answer is obviously...
yes, but it would be difficult to determine the exact effect on retail selling prices. Any such changes have been masked by other changes, such as changes in the cost of farming, increased marketing margins, changes in package size and types, and even changes in process formulas. For some items that can be directly compared over a period of 20 years, for example, frozen peas, data can be assembled that show retail prices have not increased proportionally as much as the general price level.

A study conducted by the Department of Agriculture in 1953 provides comparison of cost of actual meals from home prepared, partially prepared, and ready-to-serve foods. The study included an evaluation of quality and time to prepare the comparable meals from different types of foods. It included meals for 2 days for a family of four, including two teen-age children. The meals were described as being a little more varied and expensivethan the everyday meals of most families.

It took the homemaker 5.5 hours a day to make home-prepared foods, in which bakery bread was about the only prepared food. When she used partly prepared foods, which included such things as apple pie from canned apple and bakery mix, about 3.1 hours were required for preparation. When ready-to-serve meals were used, 1.6 hours were involved. The latter included frozen apple and beef pies but not a frozen complete dinner. The meals cost 4.50 dollars for the home-prepared foods, 5.80 dollars for the partly prepared foods, and 6.70 dollars for the ready-to-serve foods for the family of four for a day.

The home-prepared meals were liked best, but those from partly prepared products were considered nearly as acceptable. Meals from ready-to-serve foods were less acceptable. Individual foods within each group, of course, differed in acceptability. The quality of home-cooked foods would certainly depend on the cook. In this study, trained home economists were the cooks. Some homemakers might not do so well, but most homemakers have the knack of preparing foods the way their families like them.

The rapid rise of convenience and variety foods leads us to expect more of them, if the general economic situation is favorable. Consumers have demonstrated that they place convenience high in their choice of foods. Processors will probably pack an increasing percentage of foods in concentrated or semiconcentrated form in order to offset as much as possible mounting costs of labor, supplies, and distribution.

Many processors and food researchers expect expansion of what they call combination processes—the use of processing steps that have especially good features. Dehydrofreezing is an example. The excellent container for canned foods might be more widely used for dehydrated and frozen foods. Canned and dehydrated foods might be stored at reduced temperatures (40° to 60° F.), but not at freezing temperature. Irradiation might serve as a supplementary step for any of the usual preservation methods. Perhaps more fresh foods will be pasteurized. We cannot exclude the possibility of radically new processes.

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