Processing Fruits and Vegetables

There are several reasons for processing fruits and vegetables. One is to arrest decay. The moment produce is harvested, it starts to deteriorate—from the action of its own enzymes, from the oxygen in the air, and from outside microorganisms. Another reason for processing is to make a product more convenient for people to use by peeling it for them, chopping it, squeezing it, seasoning it, and cooking it. Yet another reason is to transform a fruit or vegetable into an entirely different product, like plums into prunes, grapes into raisins, tomatoes into catsup, or cabbage into sauerkraut.

Consumers today buy many more processed foods than they did in 1940, when the regional laboratories began. The increase is due in part to the improvement in frozen foods, new food products, and invention of the microwave. But it also reflects the increased willingness of Americans, including a much larger proportion of women who work outside the home, to pay a higher price for faster, more convenient meal preparation, provided, of course, that the products meet their criteria for flavor and texture.

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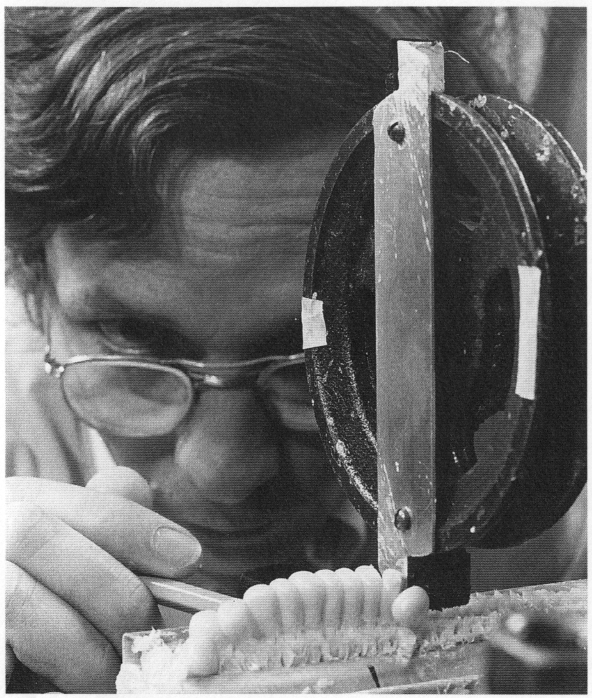
Food Process Engineering

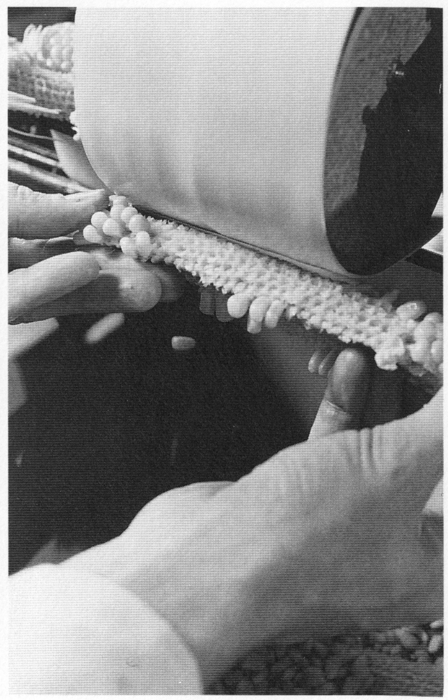
Fifty years ago, when Americans bought much more of their produce fresh, the machinery of food processing in the typical kitchen included an orange squeezer, a grater, a potato masher, and the ubiquitous paring knife. But processing tons of food in a plant requires far more complex and ingenious machinery than that. Many of the most important machines and processes used by food processors have been invented in the regional laboratories.

Building on its own considerable experience in improving dehydrated foods for the armed forces during World War II, the Western laboratory continued after the war to pioneer additional improvements in drying processes and equipment. A belt-trough dryer, an entirely new type of dehydrator, was developed when existing dehydrators proved unable to dry fruits and vegetables uniformly enough to satisfy the requirements of new preservation techniques like dehydrofreezing. In the new WRRC dryer, pieces of the product were tumbled about in the trough of a moving belt. Simultaneously, a flow of air through the bed created a fluidizing action that dried the product quickly and without reducing quality. The dryer, developed at relatively little cost, was soon adopted by several processors.

Dry peeling of fruits and vegetables was another WRRC innovation, developed in response to more stringent restrictions on disposal of organic materials in plant waste water. The dry-peeled method, first applied to potatoes, reduced organic waste loads by as much as 80 percent. It was soon applied to other crops, including peaches and tomatoes. Besides reducing wastes, dry peeling also allowed recovery of tomato peel and pulp in such a clean, concentrated form that it could be incorporated in tomato concentrates and used as food.



Designing new equipment and techniques to process whole kernel sweet corn, WRRC chemical engineer George Robertson determines exactly how much force is necessary to remove an intact kernel of a particular variety of corn from the cob.



In improved system for processing sweet corn, split ears are rotated while being pushed against revolving drum. Rubbing action removes the kernels intact. The Western lab process reduces organic wastes by up to 80 percent.

Several years later, WRRC developed a low-water, nonpolluting method for cleaning fruits and vegetables with a gentle mechanical wiping action. As an unexpected bonus, the action removed any attached stems while cleaning tomatoes, solving the problem of an occasional stem turning up in a tomato product.

The Western lab's search during the 1950's for better ways to make tomato juice powder led to development of foam-mat drying, a method eventually used by citrus processors as well. An emulsifier is added to the tomato juice and the product is whipped into a foam. It then flows like whipped cream onto conveyors, where jets of air are directed up through the tomato foam, forming little craters that help the product to dry quickly. With improvements in the dryer, the foam could eventually be dried in as little as 12 minutes. The product is then crushed into powder for later reconstitution with water.

Other food processing inventions created in the California laboratory include:

- Drum-dried fruit flakes, currently in use to make instant applesauce.

- A helical sterilizer, which cooks delicate particulate foods like diced tomatoes without damaging them.

- A high-solids vacuum evaporator, known as the WURLING evaporator. It produces tomato paste with solids contents of from 40-45 percent, compared to 30-32 percent with conventional evaporators. The evaporator is used by canners in the United States and Italy.

- A comprehensive system of reverse osmosis as a low energy alternative to evaporation. The product suffers no heat damage or loss of flavor and aroma. Processors are using the system today to produce tomato concentrates; the dairy industry uses a similar process to recover milk solids from whey.

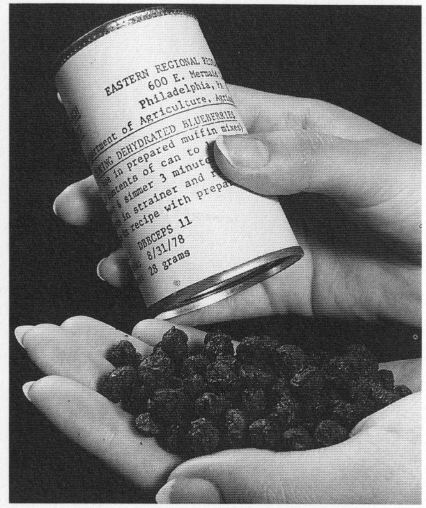
At Wyndmoor, ERRC took a different approach to drying fruits and vegetables. Researchers there had observed that many dried foods rehydrated slowly and incompletely in boiling water. Even then, they sometimes contained areas that were tough, dry, and unappetizing. To surmount this shortcoming, ERRC modified the dehydration process, introducing a step it called explosion puffing. A partially dried apple piece, for example, is subjected briefly to high temperature and pressure, then released into the atmosphere, where it explodes, or expands instantly. The result is a lightweight, porous piece of apple. It can undergo further drying more quickly than an unexploded apple piece and reconstitutes in water quickly, fully, and evenly. Scientists found that this fast, gentle treatment is competitive with commercial air drying. Explosion puffing is now used in the United States to dry apples, blueberries, and carrots, and in foreign countries for potatoes and other vegetables. Modifications of the process are also used in the spice industry.

Foam spray drying, another ERRC development, was a response to industry's need for an economical way to dry high sugar/high acid products like cottage cheese whey. Moisture is difficult to remove from such products. In the process, air under pressure is introduced into the feed line between a pump and spray nozzle. The forced air turns the product being dried into a foam, which is then sprayed over a large surface area. The foamed droplets are easily dried and reconstitute well. A modification of foam spray drying is used by industry today to make powdered fruit juice and chocolate beverage powder.

In 1961, the Western lab treated high-moisture prunes and other dried fruits with potassium sorbate to prevent mold growth. High-moisture dried fruits are tenderer and more succulent than conventionally dried fruits. With sorbate, they can be packed in plastic bags or cartons without fear of spoilage. Industry adopted the practice in 1963.

New and faster methods of drying raisins, America's largest dried fruit crop, were also developed by WRRC chemists and engineers. Grapes are not usually ready for harvest in California until September, when there is often a chance that an early rain might damage them during their 2 or 3 weeks of exposure while drying in the sun. In 1978, for example, a disastrous rain cut raisin production from an expected 270,000 tons to about 100,000 tons.

To reduce the risk of rain damage, WRRC, in cooperation with California State University, Fresno, developed a water emulsion



Explosion-puffed dehydrated blueberries were an ERRC innovation. The technique can also be used to preserve apples, carrots, and other products.

Among the many uses today for explosion-puffed produce are dry mixes for blueberry muffins.

ERRC scientists first developed a way of measuring "browning." Then they found various chemicals, including derivatives of vitamin C, that could prevent it, and with no detectable change in taste.

Lowering Fruit Moisture with Osmosis

When you sprinkle sugar on fresh strawberries and the juice oozes out to make a syrup, you are witnessing osmosis. It is defined as the tendency of a solvent to pass through a semipermeable membrane, like the wall of a strawberry cell, into a solution of higher concentration. The solvent (in this case, the strawberry juice) will continue to pass into the syrup until concentrations are equal on both sides of the membrane.

WRRC researchers have found that osmotic concentration is a practical, low-energy way to remove half the moisture from apples, peaches, and apricots without hurting the fruits' flavor, color, or texture. Traditional ways to reduce moisture in fruit pieces include hot-air drying, which requires large inputs of energy.

In the laboratory, cut-up fruits were immersed in a 70-percent sugar syrup. After 6 hours at about 160° F, enough internal moisture had migrated from the fruit to dilute the syrup to a 60-percent concentration. Researchers found that they could reconcentrate the diluted syrup back to a 70-percent concentration and reuse it five times without affecting fruit flavor or appearance.

spray containing a vegetable oil derivative that accelerates drying. Normally, the waxy outer layer of a grape acts like wax paper to keep the moisture in. The spray, by interacting with the waxy layer, allows internal moisture to escape faster so that grapes dry in about half the time. Two other approaches to drying raisins make use of inexpensive solar collectors—long tunnels of black polyethylene plastic that heat the air and speed drying. Both solar methods reduce drying time for raisins by about 40 percent.

In the South, cooperative research with the North Carolina Agricultural Experiment Station and with industry led to development of pasteurization for pickles, necessary to prevent growth of the wrong kind of microorganisms. The process proved adaptable to continuous and batch operations, and commercialization led to rapid expansion of fresh-pack pickle products. In addition, soft pickles were practically eliminated after scientists identified the enzymes responsible for softening during brining. As a result, the industry altered its processing.

Lightly Processed Fruits and Vegetables

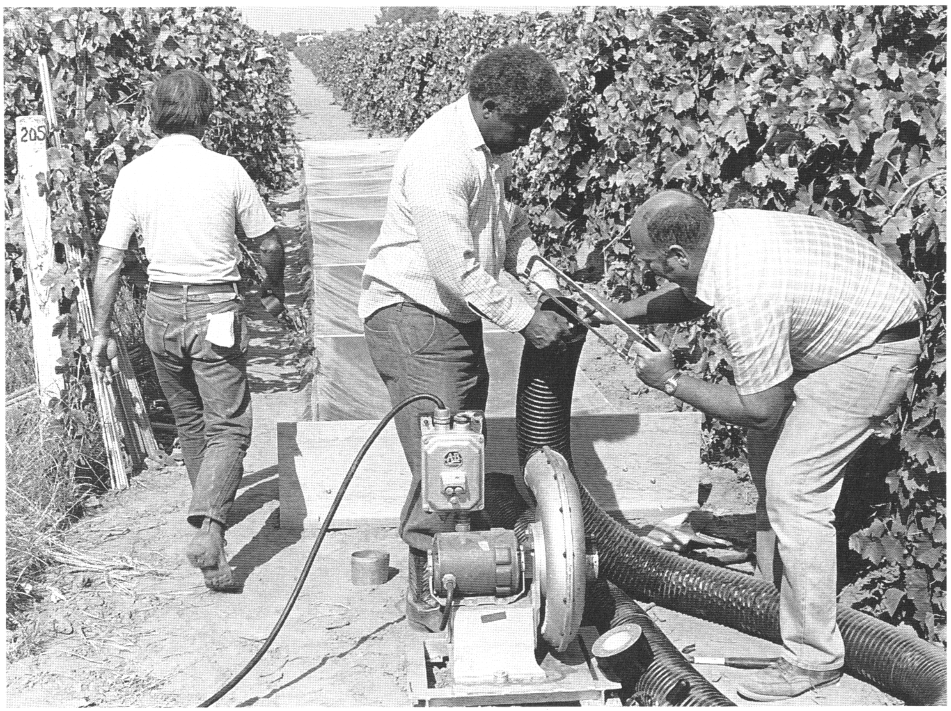
Consumer demand continues to increase for produce with freshlike appearance and flavor that is either ready to eat—or almost ready. The selections at restaurant or supermarket salad bars are but one example. For a time, normal discoloration of pre-peeled and pre-sliced raw fruits and vegetables was temporarily prevented by spraying them with sulfites. In 1987, however, the Food and Drug Administration banned the use of sulfites for controlling browning because some people—primarily asthmatics—are allergic to them. Several ARS research facilities, including the laboratories in Wyndmoor and Albany, began looking for substitutes for sulfites. They have already found several.

At ERRC, the focus was on browning, weight loss, and softening of apples, pears, and potatoes. Most browning of fresh fruits and vegetables is caused by food enzymes. A team of six scientists first developed a method for measuring enzymatic browning and then found various chemicals that could prevent it. Several related compounds are derivatives of vitamin C, or ascorbic acid. When used as a dip for fruits and vegetables, they gradually release vitamin C to keep dark pigments from forming. One such compound, tested on apples and potatoes, prevented discoloration for 48 hours. Researchers could detect no change at all in taste.

Another ERRC approach uses carbohydrate compounds called cyclodextrins to prevent natural components in juices from turning brown. Cyclodextrins are derived from cornstarch and can prevent browning in refrigerated juices. Further research is under way to control browning of juices by removing the natural enzymes responsible.

Scientists at the Western lab have pursued other avenues of research in improving lightly processed foods. They are exploring, for example, new and cleaner slicing techniques that use lasers or powerful jets of water called water knives. The idea is to control growth and spread of bacteria and other microorganisms that attack freshly cut produce. They have also discovered that an edible solution of zinc chloride delays browning of sliced apples, pears, and peaches for days or even weeks—if the fruit is bagged quickly and refrigerated after its zinc bath.

Other WRRC researchers have created edible coatings made from the casein in milk to protect the flavor, color, texture, and nutritional value of freshly cut fruits and vegetables. The nearly invisible, tasteless coating becomes in effect an artificial, edible peel. It walls out microorganisms that cause decay, traps moisture to keep the produce fresh, and lets it breathe on the shelf. In laboratory tests, small pieces of sliced and peeled apple dipped in the casein-based liquid stayed fresh for several days. Other safe-to-eat films could be made from proteins, as in soybeans, corn, or wheat.



Food technologist Rogernald Jackson holds while agricultural engineer Charles C. Huxsoll of the Western lab trims plastic tube for snug fit onto electric blower. Air will be circulated between polyethylene sheets, which will form a solar tunnel to speed drying of grapes for raisins.

A chemist at the Western lab has also found a way to keep pre-peeled and bagged carrot sticks from discoloration by a harmless but unattractive white film. One answer is to dip the carrots in a hot solution of citric acid, followed by a quick dunk in cold water to prevent heat damage. Carrots so treated are additive-free and will retain their original bright color for at least 3 weeks in cold storage.

Soft-rot, a major cause of postharvest losses in fresh fruits and vegetables, is caused by microbial enzymes. It can occur whether or not the produce is processed. ERRC researchers have been studying the genetic structure of bacteria producing the soft-rot enzymes and are investigating two approaches to their control. One is the use of naturally occurring molecules that act as bacterial antagonists. The other is the use of a chemical called EDTA, which is shorthand for ethylene diamine tetra-acetic acid. EDTA inhibits the action of the bacterial enzyme, and in laboratory tests, it protects potatoes and green peppers from soft-rot.

Selecting Varieties for Processing

Not every fruit or vegetable, no matter how delicious when fresh, will stand up well to processing. The New Orleans laboratory has for many years evaluated new breeding lines of fruits and vegetables for their processing properties. The evaluation, which is carried out in cooperation with Federal, State, and industry scientists, takes place before the variety is released. It has proved invaluable in discouraging farmers from planting varieties unsuitable for processing. Even those farmers who grow produce primarily for the fresh market prefer to plant dual-purpose varieties in case oversupply pushes fresh market prices down to profitless levels.