For Consumer Value: New Technologies Extend Shelf Life of Fresh Fruits and Vegetables

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Fruits and vegetables are enjoyed by many Americans for their flavors, colors, and textures. They are an important part of a healthy diet, as they provide a number of essential nutrients and dietary fiber. The Dietary Guidelines for Americans, developed by USDA and the U.S. Department of Health and Human Services, recommend that we eat plenty of fruits and vegetables.

With today's fast-paced lifestyles, many people do not have the time to pare, core, slice, or dice fruits and vegetables. Yet, many prefer not to use canned or frozen foods because they want the flavor and texture of fresh commodities. There is a similar trend in hospital, industrial, and school cafeterias. Generally, in such cafeterias, which typically serve 300-500 persons, manual fruit and vegetable preparation is too expensive, and machines for such a small volume are not cost-efficient. The best solution for this food preparation problem is to process produce at some centrally located area and ship the prepared fresh fruit and vegetable products to the consumer or cafeteria.

Considering the time required for packaging, shipping, distributing, and storing, one can estimate that 15-20 days will elapse between the start of processing and the time when the processed produce will reach the consumer. Unfortunately, the removal of the natural outer tissues from agricultural products immediately starts various physical, biochemical, and microbiological processes that will reduce flavor, taste, freshness, and consumer acceptance. If the processed fresh fruits and vegetables could be protected from desiccation, enzymatic and biochemical changes, and microorganisms for 2-3 weeks, it would be possible to process produce on a large scale at a central location and get fresh, nutritious products to consumers, both domestic and foreign, in an aesthetically pleasing form. USDA research is making this possible, without threatening the nutritional quality of the product.

Edible Films

If the surface of the fresh fruit or vegetable could be uniformly covered by an edible material that acts as a barrier to water and oxygen, the stability problems could be diminished. Three major classes of materials are used in edible films: proteins, carbohydrates, and fats. It is not surprising that, individually, these materials do not provide the desirable protection for the preservation of freshness, but scientists at the Western Regional Research Center (WRRC), ARS, Albany, CA, found that their combination, in the right ratio, could be very effective. A composition of 1 percent alginic acid (a carbohydrate), 10 percent casein (a protein), and 15 percent "Myvacet" (a commercially produced fat-derived ingredient) decreased water losses from apple pieces by almost 80 percent. Coated apple, pear, and zucchini pieces retained their freshness for 4-5 days without any noticeable changes. The film does not alter the taste of the coated products, and it does not have to be removed before consumption.

Edible films can also be used on bread, pizza dough, cakes, etc., to prevent these freshly baked products from becoming soggy.

Preventing Discoloration

Many raw fruits and vegetables become brown or show other kinds of discoloration when they are peeled, sliced, or juiced. To prevent such discolorations in apples and potatoes, scientists at the Eastern Regional Research Center (ERRC), ARS, Philadelphia, PA, have developed treatments that apply "browning inhibitors" to peeled fruit and vegetable surfaces. These inhibitors (ascorbic acid-2-phosphates) are closely related to vitamin C, but will require Food and Drug Administration approval for food use. New approaches have also been developed to control browning in raw fruit and vegetable juices by addition of carbohydrate-like materials called cyclodextrins or vegetable

An edible coating compound developed at the ARS Western Regional Research Center in Albany, CA, promises to extend the shelf life of fruits and vegetables. The film does not alter the flavor of the coated products, and it does not have to be removed before consumption.
Keith Weller/USDA 90BW0146-10A

gums such as carrageenan. Other ARS work has eliminated whitening in pre-peeled carrots by means of citric acid dips.

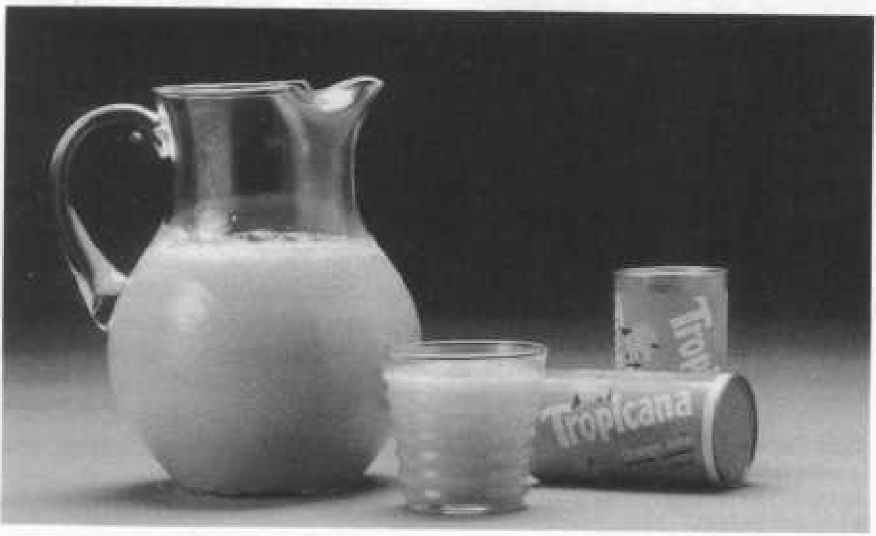
Innovative Processes for Juices and Fruits

Research work by ERRC scientists has developed innovative new processing methods for extending the shelf life and improving the quality of fruit juices. Juices can be preserved without heat pasteurization (which detracts from the fresh flavor) by using gentler physical treatments such as membrane filtration and centrifugation, a combined approach called "cold blanching." Unblemished citrus sections can be prepared by treating the fruit with pectinase enzymes to dissolve the "glue" that holds fruit segments together. This approach, developed by the Quality Improvement in Citrus and Subtropical Products Station, ARS, Winter Haven, FL, was recently commercialized by a major citrus processor.

Research conducted at the Appalachian Fruit Research Station (AFRS), ARS, Kearneysville, WV, on the composition and suitability for processing of new berry varieties contributed to the introduction of a new thornless blackberry variety called Chester, which shows superior quality characteristics and is suitable for freezing.

Explosion Puffing—A Preservation Process for the 21st Century

Drying is an ancient yet still excellent method of preserving foods. Since



ARS researchers have developed a process for extending the shelf life and improving the quality of fruit juices. Juices can be preserved without heat pasteurization.

Keith Weller/USDA 90BW0688-16

fruits and vegetables consist of 80-97 percent water, removing most of the water not only preserves the food, but also greatly reduces the weight and therefore the cost of shipping. When beans or rice are dried, the product is excellent. Dried grapes are raisins and dried plums are prunes. But, drying also has disadvantages. Produce such as apples, blueberries, potatoes, and carrots, although well preserved when dried, unfortunately are difficult to rehydrate—frequently requiring 30 minutes or more.

Engineers at ERRC, ARS, Philadelphia, PA, have made improvements in dehydrated food products. They developed a process that makes dehydrated fruit and vegetable pieces able to rehydrate rapidly so that they cook more quickly. The food returns virtually to its original size and shape with little loss in flavor, texture, and nutritional value.

The three major classes of materials used in edible films are proteins, carbohydrates, and fats. The coating acts as a barrier to water and oxygen.
Keith Weller/USDA 90BW0150-22

First, the food is appropriately processed in preparation for drying. For example, blueberries are washed; potatoes are washed, peeled, sliced, sized, given the "Philadelphia cook" (a special blanching process that improves the textural quality of the potato pieces), and cooked; and apples get peeled, cored, and sliced. After the food is prepared, it is dried by a process that differs from traditional air-drying. The drying process is interrupted when the moisture drops to about 20-30 percent, depending on the commodity, and is then resumed in a continuous-explosion-puffing machine. The machine consists of two inlet valves, a steam-jacketed main heating chamber, an outlet valve, and an explosive discharge valve. A feed conveyor transfers partially dried fruits or vegetables into the feed chamber. The feed chamber is pressurized to the same level as the main chamber and the food pieces are then transferred to the main chamber and exposed to superheated steam for about 30 seconds. At the exit, the pieces are explosively discharged through a special valve.

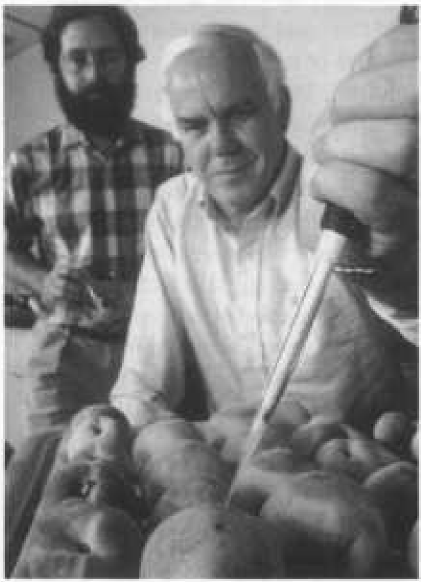
Research in the ERRC kitchen shows explosion puffing improves the texture and appearance of food. Because explosion-puffed foods are porous, they can be rehydrated quickly. In 5 minutes, the food can be cooked and ready to eat. Generally, cooking time for fruits and vegetables can be cut by as much as 80 percent over conventionally air-dried products. Some of the puffed foods can even be eaten as a crunchy snack, without cooking.

The continuous-explosion-puffing process has been demonstrated on various foods, including potatoes, carrots, apples, blueberries, celery, strawberries, cranberries, and many more. Explosion puffing has been commercialized on carrots and blueberries in the United States and on potatoes in Canada.

Fending Off Rot in Apples, Peaches, Citrus, and Potatoes

Antagonistic Yeasts. It is estimated that 25 percent of our harvested fruit is lost to decay. Customarily, fungicides are applied to fruit after harvest to control these losses, but effective alternatives to these chemicals are needed. ARS Scientists at laboratories in Kearneysville, WV, Byron, GA, Wanatchee, WA, Fresno, CA, and Philadelphia, PA, have discovered that antagonistic micro-organisms, which normally inhabit the surfaces of fruits, can be isolated and applied as "living fungicides" to control postharvest rots. These organisms have been known to effectively control rots of peaches, apples, citrus, and grapes. Of particular interest is that, among the antagonistic micro-organisms, yeasts have been discovered that block rot-causing fungi by occupying the wound sites on the fruit where infection has occurred. Here, these yeasts outcompete the rot pathogens for nutrients and space and thereby prevent decay.

Antagonistic Bacteria. Scientists at ERRC, ARS, Philadelphia, PA, are studying biological control strategies for soft rots that are caused by bacterial plant pathogens. They have succeeded in isolating and identifying 27 strains of bacteria that inhibit the growth of the most destructive soft-rotting pathogen, *Erwinia carotovora*. One antagonistic bacterium *(Pseudomonas putida* PP22*)* produces an antibiotic compound that is effective against a broad spectrum of bacterial plant pathogens, including 24 strains of soft-rotting bacteria. This antagonistic bacterium sup-



For after-harvest protection against rot, plant pathologists Charles Wilson (right) and Randy McLaughlin inoculate Red Haven peaches with a strain of yeast. The yeast outcompetes the rot pathogens for nutrients and space, thereby preventing decay.
Keith Weller/USDA 92BW0833

pressed the development of soft rot in potato tubers in three out of four trials and has potential as a biocontrol agent for reducing bacterial spoilage of vegetables.

Ultraviolet Light. Another pioneering study of approaches to control fruit rots by scientists at the AFRS, ARS, Kearneysville, WV, has shown that fruit has a hidden resistance to rot fungi. This resistance can be "turned on" with low-dose treatments of ultraviolet light. As fruit ripens, it becomes more susceptible to infection by rot organisms. The ultraviolet treatment appears to work in part by slowing fruit ripening, thereby delaying susceptibility to decay and extending shelflife, and by stimulating the production of natural fungicides within the fruit. These treatments have extended the shelf-life of peaches, apples, and citrus by weeks.

The new technologies being developed for the biological control of postharvest rots have a number of advantages over present technologies. By using natural organisms and preexisting defense systems in fruits and vegetables, ARS scientists hope to achieve postharvest rot resistance methods that are effective and safe alternatives to synthetic fungicides.

Moving Genes To Enhance Freshness

How often have you gone to your refrigerator for a fresh fruit or vegetable and come face to face with a small pile of mush, or had to cut out "bad" pieces before eating or cooking produce? ARS scientists are trying to understand what happens to fruits and vegetables during their natural ripening process and after they are harvested so that new genetic lines can be developed to maintain the quality of produce until it reaches consumers' tables. During storage, decreases in quality lead to losses of as much as 25-50 percent of all fresh produce harvested in the United States. This amounts to about $5 billion yearly. Thus, it is imperative to understand the underlying mechanisms that control the ripening process.

For a number of years scientists at the Beltsville Agricultural Research Center, ARS, Beltsville, MD, have studied ethylene, a gaseous ripening hormone in fruit. Recent experiments with gene transfer techniques at the ARS Plant Gene Expression Center in Albany, CA, have shown the importance of this hormone during the fruit ripening process. In these experiments, scientists removed and altered the gene for 1-aminocyclopropane-1-carboxylic acid (ACC-synthase), an enzyme that leads to production of ethylene. They then inserted this altered gene into tomato plants. The fruit from these genetically modified plants produced defective ACC-synthase, which consequently produced no ethylene, and the plants did not ripen.

In addition, the Beltsville scientists have discovered that sugars called N-glycans can control the *rate* of tomato fruit ripening. After N-glycans were put into green tomatoes, ripening was either enhanced or delayed, depending on the amount added.

These studies to control the ripening process will permit the produce industry to provide abundant supplies of tomatoes and other fresh fruits and vegetables year-round with no loss of nutritional value. Millions of dollars in refrigeration costs and spoilage losses will be saved as a result of these technologies. ❑

Protecting the Environment

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In the mid-20th century, agricultural science presented farmers with a class of "miracle" tools: synthetic, or manufactured, chemical pesticides. Pesticides helped farmers profitably produce an abundance of high-quality food and fiber. But there are concerns that those "miracle" products, as used, can have undesired side effects for the environment and human health. Future farmers must look for ways to produce the expected quality and quantity of food and also to eliminate, or drastically reduce, the causes of these environmental and health concerns.

The Problem

Most of today's synthetic chemical insecticides kill target pests by poisoning their life functions. Materials that are toxic to nearly all animals are called broad-spectrum insecticides. When they are applied, nontarget animals that happen to be in the environment are also affected. When misused, such pesticides can pose hazards to humans.

Aside from environmental and safety concerns, these pesticides have a doubtful long-term usefulness because of the speed with which many pests become resistant to them. Resistance is especially prone to develop when a pesticide is used as the single method of control on generation after generation of a pest. Often, after several generations of such exposure, the pesticide no longer works.

Science must devise ways to control pests while affecting little or nothing else in the environment and, for good measure, make it tough for the pest to adapt. This is not a pipedream.

Some solutions are here now, and others are on the way. These new, environmentally benign ways to control pests are the product of novel applications of advances in scientific knowledge.

Agricultural Science Responds

Some caveats exist in this search for environment-friendly products and approaches that farmers can use in farm-