Role of Enzymes in the Commercial Processing of Fruits and Vegetables

M. A. Joslyn

Enzymes, promoters of vital chemical activity in plant and animal cells, play an important role in food processing. Important transformations, some beneficial, some detrimental, are induced in fruit and vegetable products.

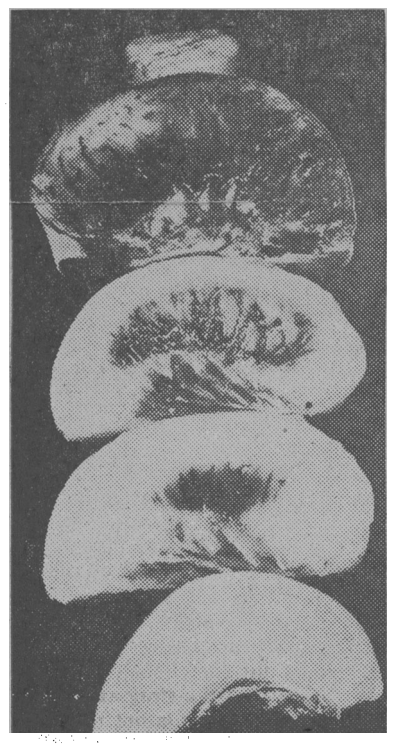
The oxidizing enzymes cause the rapid browning of cut fruits, the browning of wine and fruit juices, the reddening and bluing of potatoes. In addition to the discoloration that detracts from the appearance of the product, changes in nutritive value and flavor also occur as a result of the unrestricted activity of these enzymes.

The hydrolytic enzymes, another important group of enzymes which can act in the absence of oxygen, induce changes in wines, foods preserved by freezing, fruit juices and other products.

Enzyme Activities

Those two groups of enzymes, as well as others, are concerned in promoting the changes in color, flavor and texture during ripening of fruits and vegetables, and subsequently in the breakdown of these products during storage and distribution. Even the changes produced by bacteria, yeasts and molds which find their way into the plant tissues are caused by the enzymes which these micro-organisms contain.

The alcoholic fermentation of grape juice and of other fruit juices in the production of wines, the acetic acid fermentation in the production of vinegar, and the lactic acid fermentation in the production of pickles, are examples of useful transformation produced by enzymes of the selected yeasts or bacteria.



Sections of freestone peach halves subjected to heat to stop enzyme activity. Scalding times were, from top to bottom; 0, 3, 6, and 9 minutes. Dark-colored areas indicate unstopped enzyme activity.

The softening and rotting of fruits and vegetables and the products of activity of organisms involved in spoilage are examples of undesirable changes.

Knowledge of the nature of enzyme and of enzyme activity is necessary in developing better storage practices for fresh produce, in selection of varieties that are most adaptable to existing processing methods, and in improving processing method.

Discoloration of Apples

Each enzyme acts in a specific manner upon a particular chemical constituent or closely related group of compounds. It is necessary to know the types of enzymes naturally occurring in a particular fruit or vegetable, the chemical substance called substrate on which it acts, and the conditions governing its activity.

The browning of apples requires the interaction of an oxidizing enzyme, the oxygen of the air, and a substrate. The rate and intensity of browning is influenced by the degree of active acidity, temperature, concentration of enzyme and concentration of substrate.

The actual color change may be due to the complex transformation in the substrate or to an induced oxidation by the primary product of oxidation — quinone — of other substances present. This latter reaction is involved in the rapid loss of Vitamin C in browned apples or apple juice.

Means of Control

Discoloration of apples which occurs after the induced oxidation of Vitamin C by the quinone can be controlled by:

(1) Selecting apples whose content of the oxidizing enzyme is low—ripe apples have less than green ones, and certain varieties such as Gravensteins have less than others;

(2) Increasing the acidity—the higher the acidity, the lower the rate of activity;

(3) Decreasing the substrate concentration—the lower the concentration of catechol tannins, the less the extent of browning;

(4) Decreasing the exposure to air —in the absence of the oxygen of the air, no action will take place;

(5) Addition of substances which inhibit enzyme activity— sulfurous acid or its salts, table salt, or Vitamin C, high concentrations of sugar, etc.;

6) Or, by destroying the enzyme—which can be done readily by heat. Scalding can be used when it does not produce undesirable changes in flavor and texture.

All of these methods have been applied in the treatment of prepared apples for bakers' use, and the success which they have had is testified to by the large proportion of the apple crop that is treated in the preparation of peeled, cored and sliced apples for use as fresh or after freezing.

In the recommended process for preparing apples for bakers' use, the cored, peeled and sliced apples are treated first with a light salt brine, then immersed in a sulfite solution containing 0.4 per cent sulfur dioxide for three minutes and dispensed as such or frozen in sealed containers for subsequent distribution.

Apricots and Other Fruits

Similar processes for enzyme control in apricots, peaches and other fruit have been developed, tested under commercial conditions, and then used by the industry.

The use of syrup for the better preservation of color and texture in the packaging of berries and small, whole fruits, and for cut fruits, was first proposed by this Division, and its use is now widespread.

Scalding to Destroy Enzymes

It is well recognized that enzymes can be destroyed by heat, but the conditions under which this could be accomplished with the minimum injury to color, flavor, texture, and nutritive value had to be determined for each product.

Enzyme activity is reduced by storage at low temperatures, but it can occur even at temperatures of 0 degree fahrenheit or below. Subjection to low temperatures, even those as low as that of liquid air, –370 degrees F.—will not destroy enzymes.

On the basis of these findings the practice of scalding vegetables prior to freezing was developed early in our investigations of preservation freezing of vegetables.

Similarly, reduction in moisture content alone was shown not to prevent flavor deterioration in dehydrated vegetables, and these, too, have to be scalded prior to drying, in order to destroy enzymes.

The success of the present large frozen vegetable industry is due to the practice of scalding to destroy enzymes which otherwise would cause the production of undesirable off-flavors.

Inactivating Enzymes in Orange Juice

As another example of the type of investigations undertaken, the retention of the cloud in orange juice can be mentioned. Orange juice, freshly extracted and strained, contains certain pectins and gums in solution and pulp particles that give it the characteristic color and flavor.

It also contains clearing and clotting enzymes, the so-called pectin enzymes which in time will produce and undesirable clearing of the juice and a clotting or curdling of the pulp particles.

To prevent this, the pectic enzymes involved in this action must be inactivated, and this can best be done by flash-pasteurization. Flash pasteurized orange juice, whether canned or frozen, will retain more of its original character than that in which the enzymes are not destroyed.

Some Enzyme Action Beneficial

All enzyme action is not undesirable. Clearing, for example, is desirable in certain fruit products, some juices, and particularly wines. Here use is made of the clearing action of purified pectic enzymes produced by certain molds. Investigations are now underway to improve the activity of such preparations and to better control their use.

Hydrolytic enzymes involved in the preparation of cereal products, particularly in the conversion of starch into fermentable sugars, are important in the brewing industry, the production of malt syrups, and in the removal of starch haze in jellies and similar products.

The enzymes which bring about the solution of proteins—proteolytics enzymes—are useful in tenderizing meats. Space does not permit the discussion of these and of other aspects of our own investigations of fruit, vegetable and microbial enzymes, although the Division of Food Technology has conducted much research on oxidizing and pectic enzymes in relation to freezing, juice production, dehydration and wine making.

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Continuous Production of California Timber Can Yield Profitable Returns

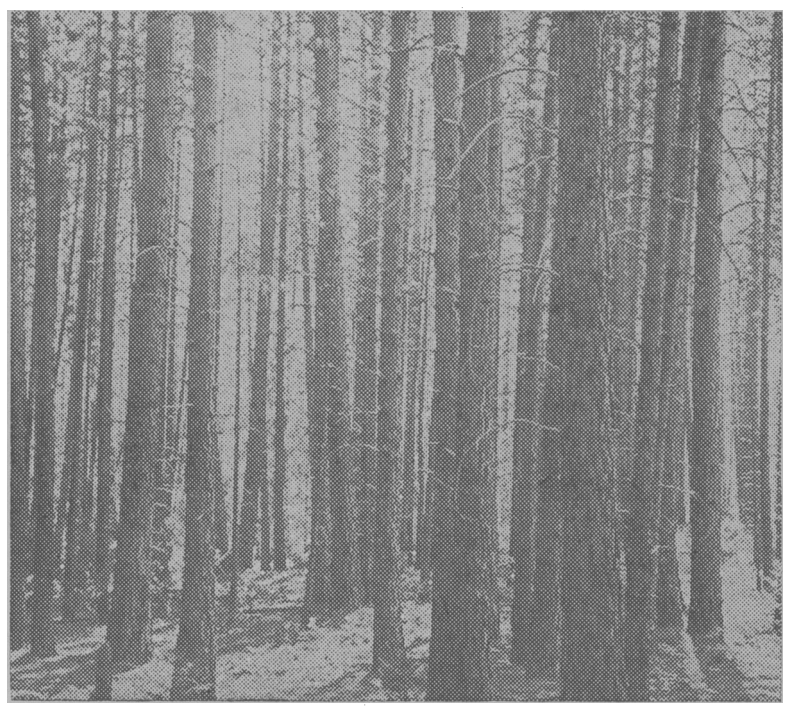
Percy M. Barr

Two types of landowner are affected by the emerging and increasing opportunities for the management of timber on a continuous basis as a permanent and profitable business—the industrial lumbermen and the farmer or other rural proprietor of a small tract of woodland.

The former is typically the owner of a considerable property of virgin timber and his problem is to adjust his cutting practices from those which leave inadequate numbers of trees to permit a second harvest in a reasonable time, to selective removals of the best stems with such a volume of annual growth on a well-stocked residual stand that successive and profitable cuts will be feasible.

Conditions in the foothill forests of the western Sierra Nevada illustrate the second type of ownership. Here there are thousands of small properties, usually of from 150 to 600 acres, where fairly well-stocked stands of second-growth between 40 and 80 years of age have resulted from the logging operations or the abandonment of farm lands during the gold-mining period of 1850-1870.

These young forests contain from 5,000 to 20,000 or more board feet per acre, with the largest stems just growing into diameters which yield logs of commercial value. Some of the tracts are farm woodlots but most frequently they are owned by people who live and work elsewhere than on their second-growth properties.



Seventy-year-old second-growth pine in Nevada County. Fully stocked forests of this type, although found on only small areas in such good condition, may contain as much as 45,000 board feet per acre, with an annual growth of 800 feet.
(Photograph by courtesy of the California Forest and Range Experiment Station)

It is estimated that about 1,200,000 acres of land in the West-side Sierra forest region of California are occupied by young forests and a considerable proportion, possibly two-thirds, of this extensive area consists of small ownerships.

Good Management, Good Revenue

In comparison with conditions in Europe and the eastern United States these second-growth stands are excellent forests and even under our less favorable economic conditions, if properly managed, they can furnish their owners with considerable and increasing revenue.

Good management of such woodlands involves two fundamentals—maintenance of their continuous productivity by protection from fire and destructive cutting, and efficient marketing of the forest products which they can be made to yield on a permanent basis.

Moderately well-stocked 70-year-old pine forests in the foothill counties contain 15,000 board feet per acre, with from 10 to 20 or more trees at least 20 inches in diameter. Such a volume commonly increases by growth at about three per cent or 450 board feet per acre annually and if fire is kept out, the natural development of new young trees will eventually improve this increment considerably.

Taxes, fire prevention, and administrative supervision may amount to about forty cents per acre yearly, frequently less.

By selecting the largest trees for cutting, either each year or at intervals of from three to five years, in a volume of 400 feet per acre annually, the net volume of the stand is not diminished and in fact the removal of this quantity may actually increase the wood increment by releasing the smaller trees from competition for light and soil moisture. At a selling price of four dollars per thousand feet of standing timber—"stumpage"—a gross annual revenue of $4.00x400/1000 or $1.60 is secured, leaving a net revenue, after expenses, of $1.20 per acre.

This can be earned year after year, continuously, for the plan which has been described does not impair the productivity of the forest because the total annual volume-increment of 450 board feet is not wholly offset by a yearly removal of 400 feet of felled timber. The forest therefore, will still gradually increase by 50 board feet or more each season.

Sixteen small properties in El Dorado County varying in size from 25 to 550 acres have been organized as Tree Farms certified by the Western Pine Association, and a recent report from Oregon describes six second-growth Douglas fir farm woodlots which, typical of many others, are being operated by their owners on a profitable permanent basis, and these average about 70 acres each.

Profitable Operating Plan

Instead of attempting to make a cut from each acre of, say, a 160-acre tract, either annually or at intervals of a few years, it would actually be more profitable and practical to divide the property into 10 blocks, cutting 10x400 or 4,000 board feet per acre the first year from the 16-acre block containing the largest number of valuable trees, repeating the operation on the next best block the second year, and so on until the entire tract had been covered in 10 years.

By such a plan logging would be more economical, being concentrated on a local area each year, while still restricting the total cut to 64,000 board feet annually, which would be less than the annual growth of 160x450 or 72,000 feet on the stand as a whole. Net annual revenue of the property would be (64x$4.00)—(160 ac.x$.40)=$192.00 or the same net earnings of $1.20 per acre.

Two Factors Causing Lower Prices

The stumpage, or standing-timber price, of $4.00 which has been quoted, while reasonable, may be higher than many California farmers or owners of small woodlots have received for their trees in recent years.

In general these lower prices have resulted from two factors—general lack of knowledge of timber values, and inefficient marketing practices.

Trees inferior to those which we have considered are selling currently in East Texas, Arkansas and throughout the southern pinelands at from $10 to $22 per thousand board feet.

It is reasonable to expect that through the development in California of cooperative log-marketing, accurate scaling of felled timber, and efficient small mills to serve owners of Sierra second-growth forests, stumpage rates of from $5 to $8 can be secured and maintained in the coming years.

Higher revenues will come from a combination of good growth rates and favorable stumpage rates. Initially, nature provides the growth but it can be maintained and improved by good forestry management. The better prices can be derived from good business management. The hills which produced gold in the 1850's can again yield revenue in the 1950's from their timber, which unlike gold is a resource of the soil that under practical, efficient forest management need never be exhausted.

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Abstracts of New Publications

The following publications are available without cost at the College of Agriculture:

ALMOND CULTURE IN CALIFORNIA, by Milo N. Wood. Ext. Cir. 103, revised January, 1947 (88 pages). Written solely from the grower's standpoint, this circular attempts to cover most of the phases of almond culture, and contains much recent material. It should have especial value to prospective growers.

FRUIT DEHYDRATION: 1. PRINCIPLES AND EQUIPMENT, by R. L. Perry, E. M. Mrak, H. J. Phaff, G. L. Marsh, and C. D. Fisher. Bul. 698, January, 1947 (70 pages). The history, statistics, advantages and limitations of fruit dehydration are covered. In addition there is an extensive discussion concerned with the pretreatment, preparation, principles and equipment of fruit-drying. Now on press.