Color Retention

pigmentation in processed fruits and vegetables is complex problem

G. Mackinney

The accurate measurement of color in a product is a very difficult matter and is usually attempted in considerably simplified form in the food industries, as for example, by canners in standardizing and in improving the color of tomato products. It is much simpler to state that a certain tomato paste has, let us say, 0.01% lycopene—the principal coloring matter of the tomato fruit—than to measure the color, which means, in effect, describing its redness in quantitative terms.

Many plant coloring matters are unstable, and may be modified by exposure to such factors as light, oxygen, acid, or unusual storage temperatures, and in this modification, they are liable to give rise to undesirable color changes. Furthermore colorless constituents may give rise to colored compounds and thus render the product less attractive.

Plant Pigments

Three conspicuous groups of plant pigments are the chlorophylls, the carotenoids and the anthocyanins.

The chlorophylls occur in all green leaves, and as their name implies, constitute leaf-green. They are invariably accompanied by carotenoids, though the reverse is not necessarily true.

Carotenoids are the principal coloring matter of carrots, apricots, yellow peaches, tomatoes, oranges, and the petals of such flowers as the sunflower, dandelion, California poppy, and so on. They range in color from pale yellow—yellow mustard flowers—to pinkish red—tomato. Both of the above groups are insoluble in water, but can be extracted from the plants with fat solvents.

Anthocyanins are present in the aqueous sap of plants. Although literally the term means flower-blue, they range in color from that found in the petal of the scarlet geranium to the red of the red rose, to the blue of the delphinium or of the bachelor button. They are not confined to flowers, but are found in many fruits—strawberry, raspberry, blueberry, cherry, red grape, both in the skin, and in the flesh of certain varieties such as the Alicante—and in the leaves—sometimes persisting throughout the life of the leaf, sometimes appearing in immature leaves, then fading and sometimes appearing in the mature leaf in the fall of the year.

A fourth group of widespread occurrence is far less conspicuously colored, and is usually masked by the presence of one or more of the above-mentioned groups. The flavones, flavonols, and flavanones are closely related chemically to the anthocyanins and are not dissimilar in behavior and properties. They are pale yellow, the color being intensified by the addition of alkali.

Three pigments in the above groups are of nutritional importance. These are carotene, the pigment first isolated from carrots and a precursor of vitamin A—sometimes referred to as a provitamin A; the flavonol rutin—found in tobacco and buckwheat; and the flavanone eriodictyol, which with hesperidin is found in lemons, particularly in the albedo, once described as vitamin P—for permeability—though the tendency now is to disallow their vitamin nature but to recognize a therapeutic value, such as an effect on the fragility of the blood capillaries.

The first three groups constitute the major problem to food processors. In addition, the two major sources of off-color formation—considering natural causes and not cases where negligence has resulted in contamination—are browning or darkening due to oxidative enzymes, and a similar discoloration due to scorching or caramelizing of the product. In the former case, tannins and similar compounds of phenolic nature are oxidized, giving rise to dark brown compounds and in the latter case, which is nonoxidative, sugars are involved, their degradation products reacting with nitrogenous constituents to give rise to humins.

Chlorophyll

Chlorophyll is susceptible to light, air, and to acids. In even weakly acidic leaves, at pH 5.5–6.0, chlorophyll slowly loses its pure green appearance and becomes olive green. Studies have been made of the rate at which the chlorophyll is degraded to its magnesium-free derivative, pheophytin.

The formation of pheophytin is particularly noticeable in inadequately blanched frozen string beans, frozen peas, and also in canned spinach. Much preliminary work was necessary before these pigments could be accurately and quantitatively measured. Chlorophyll is not easily isolated in pure form without some change.

Carotenoids

Because of the nutritional importance of carotene as provitamin A, and of lycopene as the principal coloring matter of tomatoes, these two pigments have been studied more intensively from different aspects, such as nutritional, plant breeding, processing, than other members of the group. During the war large numbers of analyses for carotene were made in this and allied divisions of the College of Agriculture to determine the nutritional value of a food, or to evaluate retention of this component as a result of some particular process treatment.

Anthocyanins

Relatively little attention has been paid to these pigments or to the changes they may undergo, with the exception of wines, where the major emphasis has been on the evaluation of color, by members of the Division of Viticulture.

About 10 years ago examinations were made of the pigments of the Alicante Bouschet grape grown in different regions of the state. The pigment content of those grown in the Napa Valley was much higher than that of those from the San Joaquin Valley. These preliminary studies were interrupted but it is hoped some day to examine in more detail the causes of instability and the difference in ease with which these coloring matters are precipitated from solution.

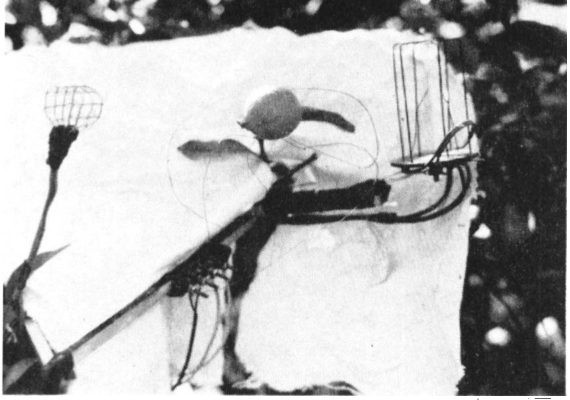
Off-Colorations

The discoloration of cut surfaces of apples, potatoes, or apricots are examples of off-colorations of enzymatic origin. The enzyme peroxidase has been studied over a number of years in many plants of commercial importance. Polyphenolases, capable of oxidizing phenolic substrates in the absence of hydrogen peroxide have also been studied by members of the Division. The studies have been of great importance in estimating correct blanching times, both in canning and for dehydration, to prevent discoloration.

The best practical examples of discoloration of nonenzymatic origin would be old samples of orange or lemon concentrates, dried apricots, or muscat raisin sirups. These darken with time until they are virtually black. As a result of laboratory studies it is now considered to be established that there is a breakdown of sugars, yielding small quantities of hydroxymethyl furfural, furfural itself, and several other as yet only partially described and not fully identified degradation products.

The breakdown of the sugars is catalyzed by the presence of certain nitrogenous compounds, and these in turn appear

Continued on page 12



Thermocouples and hot-wire anemometer used to record transient temperatures during the passage of air blast in observation of heat radiation by lemon.

FROST

Continued from page 5

but largely by thermal radiation of heat from earth to the slightly colder foliage; it is this heat transfer that keeps the air from being chilled excessively.

To reduce frost hazard under this complicated system of heat transfer it is desirable—and important—to promote heat flow into ground by day and heat out-flow by night. Hence it is advantageous to maintain the thermal conductivity of the soil at a maximum. This can be done by keeping the soil moisture up nearly to field capacity and not disturbing settled ground.

A cover crop usually increases frost hazard. A dry mulch on the surface is wrong for frost protection because in the sun it will have a hotter air surface than solid ground and thus more of the solar energy will go up in air convection and be lost than if good soil conditions had carried the heat into the ground. The dry mulch is also worse for frost than solid ground at night because with its greater thermal resistance the heat flow upward cannot match the radiation demand until the surface cools further to get a greater temperature difference from deep soil. Dry peat soil is a natural bad example. Over downtrodden grain near Davis a thermograph in July recorded a daylight temperature cycle of 98° F to 28° F.

Limitations

There has been no major freeze in southern California in the past 10 years and it is probable that when one does occur a large number of the approximately 1,000 wind machines now in use will prove to be inadequate. The observed failures of wind machines seem mainly due to too fast an indrift of cold air. Furthermore there is no expectation that wind machines will afford protection when there is a freeze with cold daytime conditions, cold soil, and no relatively warm air overhead on a clear, cold night. Since the machines do not add appreciable heat it is a mistake to start them long before needing the gain due to air mixing or forced convection. Some improvement in machine protection can be gained by lighting border heaters on the upwind side of an orchard.

F. A. Brooks is Agricultural Engineer in the Experiment Station, Davis.

R. A. Kepner is Assistant Agricultural Engineer in the Experiment Station, Davis.

D. G. Yerg, formerly research Assistant, Agricultural Engineering, is now Instructor, University of Alaska, Fairbanks, Alaska.

The above progress report is based on Research Project No. 400-U.

OLIVE

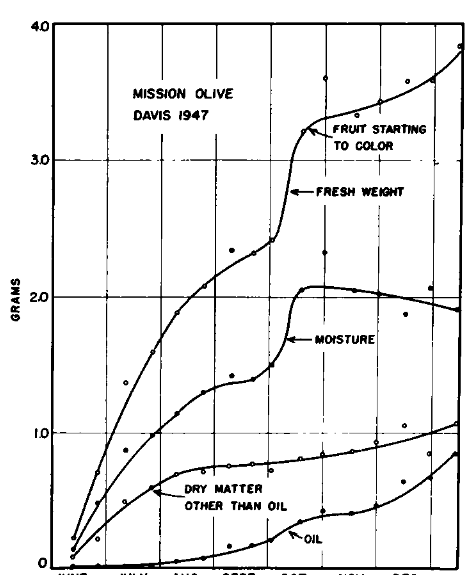
Continued from page 7

pleted in the Mission variety at Davis in 1947 by the third week in October. The Mission fruits at Davis in 1947 increased in size during the first two weeks in October as much as they had during the preceding two months.

The usual harvest period for pickling olives in California occurs generally from the first of October until mid-November depending upon the variety. Undoubtedly much of the fruit is harvested after this period of final swell. Growers who make a practice of early harvesting may not be obtaining the maximum size from their fruit which is possible.

There are other factors than fruit size, of course, which may determine the optimum time to harvest the crop. These are largely the processing characteristics of the variety which necessitates harvesting at certain stages of maturity in order to make a satisfactory product.

The sharp increase in the Mission fruit size just prior to fruit coloring in October is accounted for largely by increased moisture in the fruit. There is no particularly large increase in oil or dry weight other than oil at the time of the precoloring increase in fruit size.



Fresh weight, moisture, oil and dry matter other than oil of Mission olives during the 1947 growing season at Davis. Weight per fruit, based on average of 100 fruits.

For the grower to obtain the full benefit of this size increase it would appear necessary to keep the trees supplied with sufficient water during this period. In fact other research workers have found in the olive that when the soil moisture drops to the permanent wilting percentage it is reflected in a reduced rate of size increase, resulting in a smaller size fruit at maturation even though subsequent irrigations are given.

The Mission is the leading olive variety in California for the production of olive oil. The data obtained in the studies for oil content in this variety agree with the experience of olive growers, in that the oil content increases steadily into mid-winter. As seen in the accompanying graph concerning Mission olives, in which the oil content is expressed in grams of oil per fruit, there is an actual pronounced increase in the oil content of the fruit during December and January. In addition, during this same time there is a decrease in the moisture content of the fruit. Very few olives are harvested for oil in California before the middle of December and probably the bulk of the oil olives are picked during January.

H. T. Hartmann is Assistant Professor of Pomology and Assistant Pomologist in the Experiment Station, Davis.

The above progress report is based upon Research Project No. 1301.

COLOR

Continued from page 4

to react with the breakdown products of the sugars, giving rise to dark-colored polymers of the type rather inadequately described as humins.

Control is Complex

The control of this type of deterioration is no simple matter as yet. If the product is kept at the lowest practicable temperature, this is still the most effective means of retarding the damage and the most effective supplementary treatment is the well-known long-established use of sulfur dioxide.

Research in these various fields is slowly bringing about a better understanding of the behavior of the compounds involved and will determine procedures to be used in controlling undesirable changes.

Gordon Mackinney is Associate Professor of Food Technology and Associate Biochemist in the Experiment Station.

The above progress report is based in part upon Research Project No. 1111.