Chemical Composition and Biochemical Properties of Mirlitons (*Sechium edule*) and Purple, Green, and White Eggplants (*Solanum melongena*)

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Mirlitons and eggplants were examined for composition and enzyme activities. Mirliton seed amino acid concentrations were approximately twice those in the flesh. Methionine was detected only in the seed. Percent nitrogen and ether extract values were similar for the purple, green, and white eggplants. The white variety contained twice as much crude fiber as the purple and green cultivars. Amino acid contents were higher in the purple variety and lowest in the white. Trace elements were determined by neutron activation analysis. Activities of several enzymes (polyphenoloxidase, alcohol dehydrogenase, catalase, phosphatase, lipoxygenase, and peroxidase) were compared in the three varieties. Electrophoresis of peroxidase enzymes revealed three distinctive isoenzyme patterns among the three varieties. Tissues of the eggplant were analyzed for relative activities of specific and nonspecific phosphatases. In contrast to reports that NaCN did not inhibit eggplant lipoxygenase, in this study cyanide completely inhibited the enzyme in all three varieties.

The growing interest in nutrient composition of foods can be attributed in part to the new Food and Drug Administration's nutritional labeling regulations. In the past, little attention was paid to variations in nutrient contents of many vegetables because the breeding of new varieties emphasized higher yields or better processing and storage characteristics. Recent research on essential trace elements has stimulated investigations on the sources and availabilities of these minerals in plant foods (Leveille et al., 1974). The role of dietary fiber in the diet is also receiving considerable attention.

Eggplants and mirlitons (chayotes) are grown in tropical or semitropical climates throughout the world (Combs et al., 1973; Patnik, 1967). The purple eggplant is widely used but other varieties that differ in color, size, and shape (Jaiswal et al., 1974; Mishra, 1966) are known. A white variety has been grown in Europe for many years but apparently for ornamental purposes only (Dumonthay, 1936). A round, light-green eggplant has been grown in India (Viraktamath et al., 1963) and is now appearing in home gardens in the southern United States, but it is seldom sold in fresh produce markets. A pink and a black eggplant are cultivated in India (Singh et al., 1974) but their acceptance as a food is based on external characteristics only.

The mirlitons is a squash-like vegetable native to Central America (Whitaker and Davis, 1962). Its popularity has spread to the West Indies, throughout Southern Europe, to the southern U.S., and to Russia. It can be grown from sea level to altitudes between 4000 and 7000 feet (Singh, 1965). Tiebout (1914) noted that mirliton vines will produce fruits in the fall and early winter until the first frost in Louisiana. Seedless fruits were recently produced in the greenhouse by Aung and Flick (1976). Adverse physical and biochemical changes of the tissue can lower acceptability and nutritional value of a product. To ensure the production and marketing of fresh and processed fruits and vegetables and maximize nutritional aspects and efficiency in processing on a year-round basis, a better understanding of the initial composition and certain enzymes that catalyze biochemical changes in the vegetable during storage and before and during processing is needed.

Polyphenoloxidase (EC 1.10.3.1) is probably a major cause of discoloration in vegetables that have been subjected to rough handling, storage, peeling, and processing. This enzyme utilizes tannins and phenolic compounds in the tissue as substrates to produce brown products. Polyphenoloxidase (tyrosinase) was assayed with tyrosine (monophenol) and DOPA (diphenol) as substrates, since Louisiana eggplants were reported by Rhoades and Chen (1968) to be active toward diphenol substrates but inactive toward monophenol substrates. Knapp (1961) also reported that eggplant polyphenoloxidase was more active on the polyphenols. Catalase (EC 1.11.1.6) catalyzes the decomposition of hydrogen peroxide, which is toxic to plant cells. Alcohol dehydrogenase (EC 1.1.1.1) was reported by Hatanaka and Harada (1972) to convert the resulting aldehyde products of lipoxygenase activity to alcohols in tea seeds (hexanol to henanal). However, hexanal was also produced from linoleic acid by peanut lipoxygenase (St. Angelo et al., 1972).

Peroxidase (EC 1.11.1.7) is omnipresent in plants and is frequently encountered in research on foods or plant biochemistry. It has been used as an index of blanching in corn processing (Gardner et al., 1969; Vetter et al., 1958), processing of numerous vegetables for frozen food products (Bomben et al., 1973; Bottcher, 1975), chilling injury in harvested green bananas (Haard and Timbie, 1973), cold treatment of pear embryos (Tao and Kahn, 1976), and ripening and senescence in apples (Gorin and Heidema, 1976). It has been implicated in fresh weight and sugar yield in sugar beets (Gaspar and Bouchet, 1973), off-flavor development in orange juice (Bruemmer et al., 1976), and in postharvest fiber formation of asparagus spears (Haard et al., 1974). Changes in peroxidase activity and/or gel electrophoretic isoenzyme patterns have been utilized as indicators of disease resistance or injury in many plants, including eggplants (Popushoi et al., 1973; Seevers et al., 1971; Wood, 1971; Birecka et al., 1975, 1976; Batra and Kuhn, 1975).

MATERIALS AND METHODS

Vegetables and Reagents. Fresh mirlitons, green variety (Figure 1), were purchased in a New Orleans market. Weight of the vegetables averaged 299.5 g and ranged from 110.8–510.0 g each. Mirlitons grown in Mexico were used in the acid phosphatase study. All eggplants (Figure 1) were grown under identical conditions

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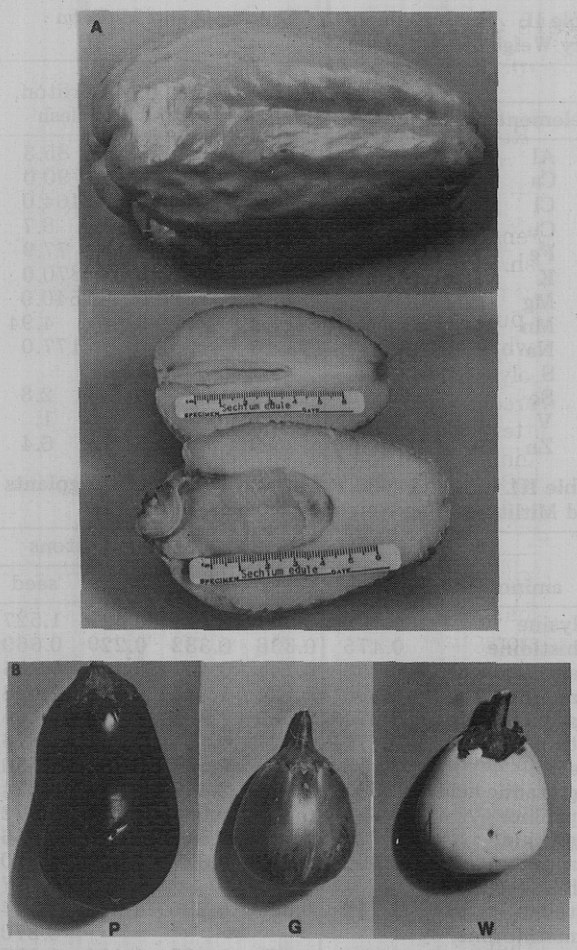

Figure 1. Photographs of vegetables: (A, top to bottom) whole mirliton, longitudinal cut perpendicular (middle) to and parallel (bottom) to the wide axis of the seed to indicate thickness and width of the seed; (B) purple, green, and white eggplants at the same stage of growth (ca. 350–400 g).

in the same outdoor plot in Chalmette, La., and were harvested at approximately the same stage of maturity. All fruit were stored in a refrigerator at 4 °C for 1 to 2 days until used. Buffer salts, substrates, and normal reagents were purchased from commercial sources. Enzymes used as standards (polyphenoloxidase, catalase, alcohol dehydrogenase, and lipoxygenase) were purchased from Worthington Biochemical Corp., Freehold, N.J., and acrylamide gel and electrophoresis reagents from Canalco, Inc., Rockville, Md.

Proximate Analyses. Nitrogen contents were determined by the macroKjeldahl method (AOAC, 1970). Proximate analyses (total solids, moisture, nitrogen, crude fiber, ether extract, and ash), pectin, and carotene contents were determined by the appropriate AOAC method (1970).

Elemental Analyses. The freeze-dried materials were ground in a food blender, mixed, and subsampled for analysis. About 1 g of each sample was weighed into a clear polyethylene vial (1.5 cm i.d. × 2 cm high) and analyzed for a range of elements by nondestructive neutron activation analysis. The samples were irradiated twice; one for about 1 min, depending on the sodium and chlorine content, and again for approximately 4 h. The neutron flux was about 10^{12} neutrons $(cm^2)^{-1}$ s^{-1} (1.2×10^{12} for the short irradiation and 1.3×10^{12} for the long irradiation). After short irradiation the samples were counted within a few minutes, and after long irradiations they were counted as soon as practicable; usually within 2–5 days. The samples were recounted after a minimum of 10 days of decay. The accuracy of the method was ±5%. An Intertechnique SA-44 4000 channel analyzer was used to collect data, which was stored on magnetic tape for later processing.

Amino Acid Content. Freeze-dried tissues of the vegetables were analyzed on a Beckman autoanalyzer using procedures recommended in the Beckman Manual (Beckman Instruments, 1972), according to the methods described by Spackman et al. (1958). Freeze-dried tissue was hydrolyzed for 24 h at 110 °C with constant-boiling hydrochloric acid in a nitrogen atmosphere in a sealed tube.

Polyphenoloxidase, Catalase, and Alcohol Dehydrogenase. Polyphenoloxidase, catalase, and alcohol dehydrogenase activities were assayed by methods described in the Worthington Enzyme Manual (1972). Extracts for the first three assays were freshly prepared by homogenizing 15 g of small pieces of fresh tissue (about 1 cm^3) in 60 mL of deionized water for 30–60 s at 0 °C in a food blender, rapidly pouring the mixture into a fluted filter paper, and immediately refiltering the first 25–30 mL of filtrate collected through sintered glass by mild vacuum. The clear extracts were placed in a crushed ice bath and assayed within 2 to 3 min.

Because rapid discoloration or peeled tissue by polyphenoloxidase activity in the purple variety occurred in our earlier work (Flick et al., 1977), extracts for these analyses were prepared in the following manner. Peeled fruit were quickly cut into small pieces and a known amount (20–30 g) was placed in a blender with 4 volumes of ice cold (3 °C) deionized water. After homogenizing at high speed for 30 s, the mixture was poured through a glass funnel containing Whatman No. 42 filter paper that was fixed directly over a sintered glass filter. When several milliliters had collected, mild vacuum was applied to further clarify the extract. Each extract was collected in a test tube, placed in crushed ice, and analyzed (within 2 min after homogenization was stopped). Nitrogen contents of the extracts were determined by the macroKjeldahl method.

Peroxidase. Peroxidase activity in the extracts was measured continuously at 460 nm in a recording spectrophotometer, with *o*-dianisidine as the hydrogen acceptor at pH 6.0 and 27 °C, essentially by the Worthington method (Worthington Enzyme Manual, 1972). Gel electrophoretic analysis of peroxidase isozymes in the extracts was performed according to Ornstein and Davis (1964), with 7.5% polyacrylamine gel and application of 3 mA/tube until the marker band moved to the bottom of the tubes. Gels were stained with benzidine according to the procedures described by Scandalios (1969).

Lipoxygenase. The lipoxygenase (EC 1.13.1.13) assay was essentially that employed for peanuts (St. Angelo and Ory, 1972), with 1 mL (0.83×10^{-4} M) of Tween-solubilized linoleic acid as the substrate and 0.1 mL of eggplant supernatant as the enzyme source. Activity at pH 6.5 was measured as change in optical density at 234 nm in a Beckman DU recording spectrophotometer for the first 5 min of the reaction. Potassium cyanide was added at a final concentration of 10^{-3} M for the inhibitor tests as reported by Grossman et al. (1972). Tubes containing enzyme plus KCN were placed in an ice bath for 30 min before testing to allow for any possible effect of cyanide to take place.

Acid Phosphatases. Activities of the following acid phosphatases were compared: phenyl phosphatase, EC 3.1.3.2 (ϕ-Pase); ATPase, EC 3.6.1.3; fructose-1,6-diphosphatase, EC 3.1.3.11 (F-1,6-diPase); glucose-1-phosphatase, EC 3.1.3.10 (G-1-Pase); and glucose-6-phospha-

Table I. Composition of Three Types of Eggplants

composition of mirlitons and three varieties of eggplants			
sample (total fruit)	moisture, %	total solids, %	pectin, %
mirliton	94.7	5.3	1.5
purple eggplant	93.6	6.4	
green eggplant	94.2	5.8	
white eggplant	92.2	7.8	

composition of solids (dry weight basis, percent total solids)				
sample	nitrogen	ether extract	crude fiber	ash
mirliton	2.9	0.6	7.6	3.6
purple eggplant	2.0	0.9	10.8	4.6
green eggplant	2.0	0.8	11.9	8.6
white eggplant	1.8	0.8	22.3	7.4

tase, EC 3.1.3.9 (G-6-Pase). Two additional substrates were examined in the mirliton study only: sodium phytate (Na-Ph) and β-glycerol phosphate (β-G-P). Acid phosphatase activity was measured as described in the Worthington Enzyme Manual (1972). Each cuvette contained 0.1 mL of 0.15 M acetate buffer, pH 5.0, 0.05 mL of 0.01 M substrate (disodium salt of phenyl phosphate, β-glycerol phosphate, fructose-1,6-diP, ATP, glucose-1-P, sodium phytate, or glucose-6-P), 0.05 mL of 0.01 M $MnCl_2$, 0.2 mL of water, and 0.5 mL of eggplant extract (or water in the blank control). Inorganic phosphorus released was determined by the Fiske-Subbarrow (1925) method from specific substrates after 45 min, pH 5.0, room temperature (25–26 °C), at 710 nm in a spectrophotometer.

RESULTS AND DISCUSSION

The composition of mirlitons and eggplants is listed in Table I. The high moisture content and low nitrogen contents of mirlitons are similar to those of eggplants. Carotene was either absent in the tissue or the concentration was too low to be detected. This agrees with Axtmayer and Cook (1933) but not with Munsell et al. (1950, who reported the vitamin A content as 0.001 mg/100 g of tissue. Mirlitons, on a whole fruit basis, contain about 0.4% crude fiber. Therefore, as a source of dietary fiber they could be nutritionally important as a supplementary vegetable.

The high water and low protein contents of all three varieties of eggplant are typical of fleshy vegetables. White eggplants contained the greatest amount of solids and green the lowest; the white variety had 34% more solids than the green. Ether-extractable compounds were quite low in all varieties. Crude protein was only slightly higher in purple and green eggplants than in white, but both the green and white varieties contained more ash than did the purple.

Crude fiber content was similar in both the purple and green eggplants, whereas the white variety contained almost twice as much. Sherman (1974) reported a negative correlation between the incidence of heart disease and dietary fiber. If this is so, the white variety could be a nutritionally important source of fiber in the diet. The data reported here agree with other published information on purple eggplants.

Elemental Analysis. Freeze-dried tissues were analyzed by neutron activation analysis. Table II lists the contents of the detectable elements. All three eggplant varieties have high concentrations of calcium, chlorine, magnesium, and potassium. Chlorine and potassium are highest in the green and lowest in the purple variety, whereas the reverse is true for sodium, copper, selenium, and magnesium. More than half of the mineral contents for the white variety appear to lie somewhere between those found in the other two varieties. A number of other elements were found but in less than the reliable limits of detection by this method.

Table II. Trace Elements in Eggplants and Mirliton (Dry Weight Basis, ppm)

	eggplant			mirliton,
element	purple	green	white	flesh
Al	123.0	76.9	132.5	85.3
Ca	1450.10	1090.0	1068.0	1790.0
Cl	2060.0	3590.0	2785.0	1464.0
Cu	21.8	13.2	14.6	8.7
Fe	164.0	180.0	157.0	77.9
K	17390.0	28220.0	27475.0	12870.0
Mg	1690.0	1245.0	1280.0	1540.0
Mn	11.7	14.8	10.0	4.94
Na	306.0	211.0	232.0	177.0
S	3800.0		9950.0	
Se	2.0	1.1	1.5	2.8
V	1.	1.	1.	1.
Zn	6.1	8.0	5.8	6.4

Table III. Amino Acid Profiles of Proteins in Eggplants and Mirlitons (Dry Weight Basis, mg/g)

	eggplants			mirlitons	
amino acid	purple	green	white	flesh	seed
lysine	0.769	0.541	0.541	0.421	1.527
histidine	0.475	0.338	0.332	0.229	0.669
ammonia	0.558	0.744	0.401	0.624	0.736
arginine	1.206	0.724	1.033	0.544	2.498
aspartic acid	3.274	2.666	1.969	1.452	2.105
threonine	0.776	0.527	0.493	0.641	0.876
serine	0.815	0.568	0.562	0.731	1.550
glutamic acid	3.582	2.992	2.405	1.973	5.274
proline	0.784	0.585	0.534	0.688	0.972
glycine	0.776	0.542	0.548	0.648	0.956
alanine	0.995	0.658	0.677	0.799	1.570
half-cystine[a]				0.035	0.097
valine	1.212	0.807	0.795	0.987	1.744
methionine[b]					0.270
isoleucine	0.722	0.655	0.638	0.696	1.297
leucine	1.266	0.950	0.944	1.208	2.694
tyrosine	0.419	0.287	0.313	0.502	0.755
phenylalanine	0.869	0.617	0.617	0.747	1.810

[a] Measured as cysteic acid. [b] Measured as methionine-sulfone.

Amino Acids. The amino acid profiles in Table III are typical of those in plant proteins; the lysine and methionine contents are low compared to animal proteins.

The seed of the mirliton was considerably higher in all amino acids than was the flesh. Methionine was found in the seed, but concentrations in the flesh were too low for detection. Arginine in the flesh (0.544 mg/g) compares favorably with that reported by Yoshimura (1922) for Japanese mirlitons (0.7 mg/g). Of the total nitrogen, 59.9% is protein nitrogen. The green and the white eggplants contained similar amounts of the 17 amino acids, except the white was higher in arginine and the green was higher in aspartic and glutamic acids. The amounts of all amino acids were higher in purple eggplants than in either of the other varieties. Cystine and methionine were not detected. The amino acid levels of the eggplants, particularly the white variety, are too low to be nutritionally important. However, if eggplants are a diet item in a country where the total protein is limited, the purple variety would have more value than the other cultivars. The total amount of amino acids (2.698%, Table III), compares favorably with the protein content calculated from percent nitrogen (2.9%, Table I).

When the copper, iron, and zinc contents in Table II are compared to the relative enzyme activities in the corre-

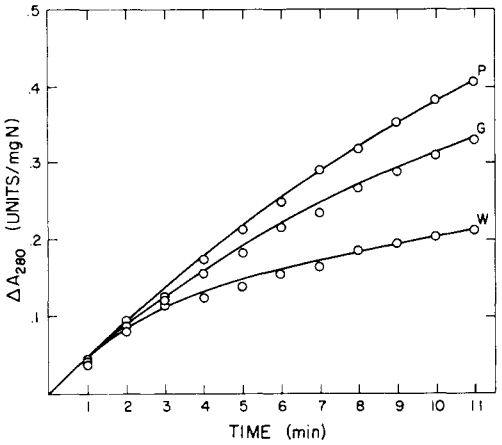

Figure 2. Polyphenoloxidase activity in purple, green, and white eggplants. Conditions are described in the Materials and Methods section except for pH 6.5 buffer and 0.5 mL of enzyme extract in test samples; no enzyme in the controls.

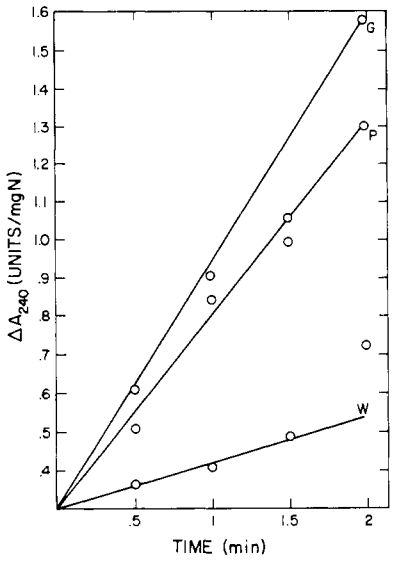

Figure 3. Catalase activity in purple, green, and white eggplants. Conditions similar to those in Figure 2 except that buffer pH was 7.0 and 0.6 mL of enzyme extract was added per test; no enzyme in the controls.

sponding varieties (Figures 2, 3, and 4), an interesting observation is noted. The three enzymes are metalloenzymes: polyphenoloxidase (Cu), catalase (Fe), and ADH (Zn). There appears to be a correlation between the amount of copper present and the polyphenoloxidase activity (purple, green, and white, in decreasing order) and between the amounts of iron in eacy variety and the catalase activities (green, purple, and white, in decreasing order). Both the zinc content and ADH activity are highest in the green variety, but enzyme activity is slightly higher in the white than in the purple, whose zinc contents are 5.8 and 6.1 ppm, respectively. Eggplant polyphenoloxidase activities (Figure 2) were highest in the purple variety, decreased in the green, and were lowest in the white. This activity was most evident during peeling. Darkening of the peeled fruit when exposed to air occurred faster in the purple variety. This was also observed by Constantin et al. (1974), who reported that green eggplant cultivars discolored less than the purple ones.

Polyphenoloxidase is not the only copper enzyme present in eggplants (e.g., ascorbic acid oxidase), and catalase is not the only iron-containing hemoprotein (cytochromes and peroxidase also contribute to this value).

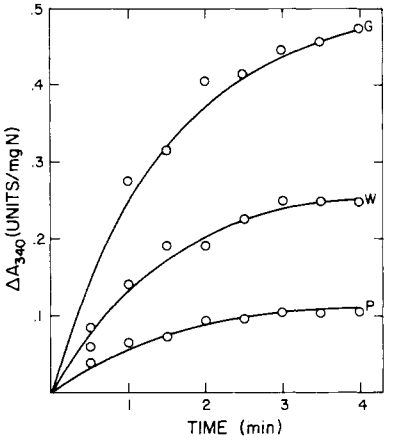

Figure 4. Alcohol dehydrogenase activity in purple, green, and white eggplants. Conditions are described in the Materials and Methods section, except that pH 8.0 buffer and 0.3 mL of enzyme extract was added per test; no enzyme in the controls.

However, there was a correlation between metal content and activity in seven of the nine samples compared. The relative amounts of polyphenoloxidase and catalase activity in the purple and green varieties may explain why the green variety is believed by some to have a milder flavor than the purple.

Mirliton extracts produced no response when either the mono- or diphenols were used as substrate for polyphenoloxidase assay. The extract was subjected to polyacrylamide gel electrophoresis in an attempt to concentrate the enzyme. The gels were placed in either substrate solution at pH 6.5 and 25 °C for 30 min, but showed no detectable activity. This result suggests that the production of bitter phenolic compounds by this enzyme would be unlikely in handling and processing of mirlitons.

Both catalase and alcohol dehydrogenase (ADH) (Figures 3 and 4) activities were highest in the green eggplant, but catalase activity in the purple variety was only slightly less than that in the green. The white had only one-third of the activities found in green eggplants. The purple variety had the lowest ADH activity. The low ADH activity found in all three eggplants (the purple variety had the lowest) tends to exclude this enzyme as a major cause of off flavors. There is no relationship between organoleptic or storage quality and H_2O_2 production, but removal of H_2O_2 by catalase might be beneficial.

Peroxidase activity was significantly higher in the white than in the other two varieties of eggplants (Figure 5); it was only slightly higher in the green variety than in the purple. The purple and white eggplant have, respectfully, two and three major bands between R_f 0.06 and 0.2, while the green variety has one minor band. All three varieties have a major isozyme band near the origin and two minor bands between R_f 0.1–0.2 (Figure 6). Between R_f 0.6 and 0.7, the white variety had three additional bands, the purple one, and the green none. All three cultivars contained major bands between R_f 0.8 and 0.9.

Peroxidation of lipids catalyzed by lipoxygenase is considered a primary cause of quality deterioration in unblanched vegetables. Lipoxygenase activity has been reported in eggplants (Pinsky et al., 1971) and the enzyme was isolated and partially characterized (Grossman et al., 1972). The isolated enzyme was reported to be unaffected by cyanide (Grossman et al., 1972). These studies were presumably done on the purple variety. Both the activity and the reaction rate for the purple eggplant were sub-

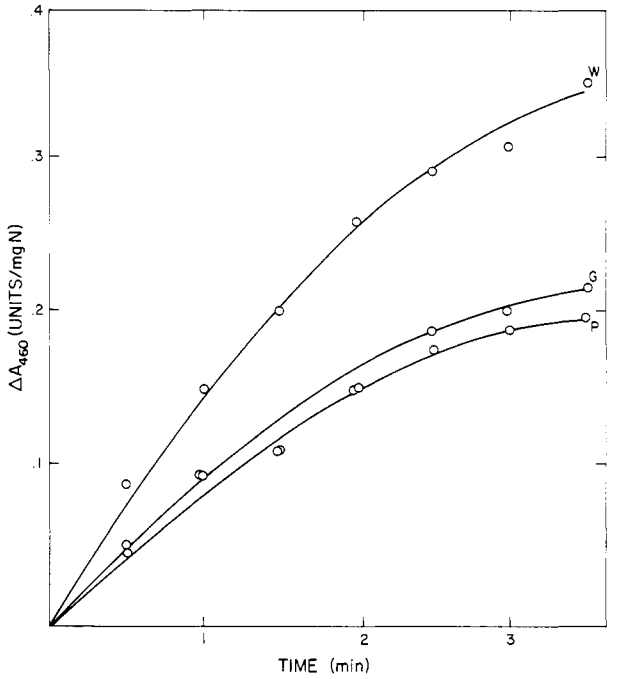

Figure 5. Peroxidase activity in purple, green, and white eggplants. Reactions run at pH 6.0; other conditions are described in the Materials and Methods section.

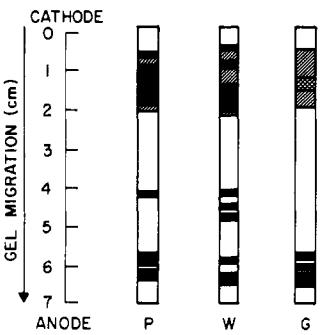

Figure 6. Gel electrophoretic patterns of peroxidase isozymes. Conditions are described in the Materials and Methods section.

stantially greater than for the green and white varieties (Figure 7). The initial reaction rate for lipoxygenase in green eggplants was faster than that for the white variety. Whether the difference was due to less active isoenzymes or to the presence of lipoxygenase inhibitors in the newer cultivars was not determined. Unlike the findings of Grossman et al. (1972), KCN completely inhibited activity in extracts of all three varieties.

Acid phosphatases occur widely and have an important effect on carbohydrate metabolism in plant tissues. They catalyze the hydrolysis of phosphate esters bound to lipids, sugars, or nucleic acids (Lehninger, 1975) and may be related to the onset and development of senescence (Baker and Takeo, 1973). Activities of detectable phosphatase activities were highest in the purple eggplant variety and lowest in the white (Figure 8). The order of decreasing rates of activities were: ATPase, ϕ-Pase, F-1,6-diPase G-6-Pase, and G-1-Pase (found only in the purple variety). The mirliton was also analyzed and yielded results similar to those from eggplant. Relative rates of phosphatase activities were highest with ATP and lowest with glucose-1-phosphate as substrates. Other activities decreased in the following order: ϕ-Pase, F-1,6-diPase, β-glycerol phosphatase, G-6-Pase, and phytase. Activities of all phosphatases were highest in the skin and lowest in the seed of mirlitons. This observation is similar to the report

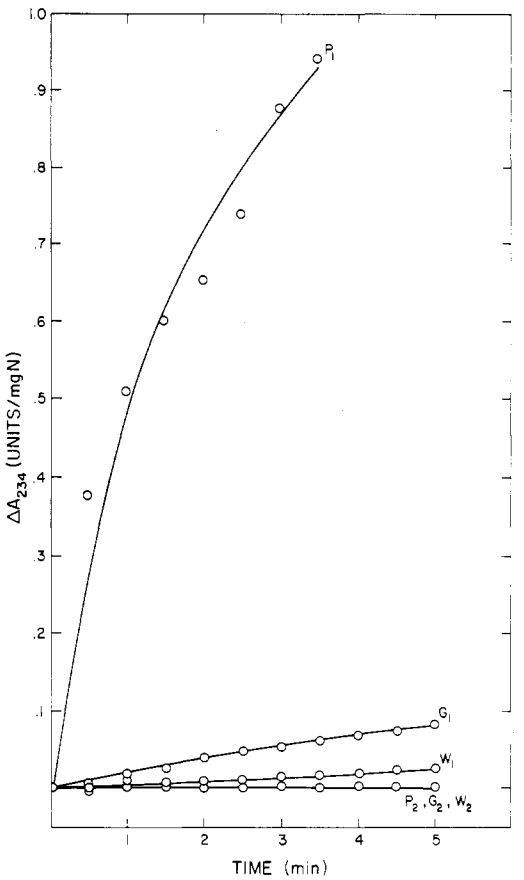

Figure 7. Lipoxygenase activity in purple, green, and white eggplants, with and without added KCN. P_1, G_1, and W_1 are activity curves for purple, green, and white eggplants without added KCN; P_2, G_2, and W_2 are curves for extracts with added KCN. Other conditions are described in the Materials and Methods section.

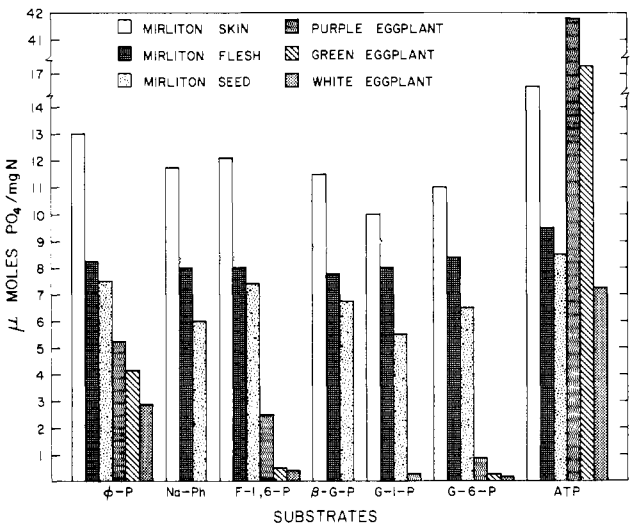

Figure 8. Phosphatase activity in mirlitons and purple, green, and white eggplants. Substrates: ϕ-P (phenyl phosphate, disodium salt), Na-Ph (sodium phytate), F-1,6-diP (fructose-1,6-diphosphate), β-G-P (β-glycerol phosphate), G-1-P (glucose-1-phosphate), G-6-P (glucose-6-phosphate), and ATP. Other conditions are described in the Materials and Methods section.

by Sacher (1975) that phosphatases are not substrate-specific in different anatomical parts of the avocado.

ATPase activity was very much higher in purple eggplants than in either the green and white varieties or in mirlitons. ATPase was also eight times higher than

ϕ-Pase in purple eggplants. Since ϕ-phosphate is not a natural substrate in plants, some of the observed ϕ-Pase activity may be due to nonspecific esterases, as was found in peanuts (Cherry and Ory, 1977). The small amount of G-1-Pase in eggplants parallels findings on ungerminated barley grains (Ory and Henningsen, 1969), in which the enzyme was not present initially but significant activity was measured after 4–6 days germination (Bøg-Hansen et al., 1974). This observation suggests that the enzyme may not be a normal constitutent of fresh seeds and vegetables. The high G-1-Pase values found in mirlitons could be related to ripening (these vegetables were picked in Tijuana, Mexico, and shipped to Blacksburg, Va., for testing). Effects of postharvest physiological changes in the mirlitons could not be determined in these analyses. Except for ATPase activity, all other phosphatases measured were higher in mirliton tissues than they were in all three varieties of eggplants.

Our results indicate that characterization of keeping quality of fresh fruits and vegetables should include a study of the biochemical properties of the species and the variety. Chemical analyses of the different varieties and the relative amounts of enzymes that can affect organoleptic properties could provide helpful information for processors and for fresh produce markets.

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LITERATURE CITED

Association of Official Analytical Chemists, "Official Methods of Analysis", 11th ed, Washington, D.C., 1970.
Aung, L. H., Flick, G. J., *Hortic. Sci* **11**(5), 460 (1976).
Axtmayer, G. H., Cook, D. H., *P.R. J. Public Health Trop. Med.* **8**, 407 (1933).
Baker, J. E., Takeo, T., *Plant Cell Physiol.* **14**, 459 (1973).
Batra, G. K., Kuhn, C. W., *Physiol. Plant Pathol.* **5**, 239 (1975).
Beckman Instruments, Inc., "Model 121 Automatic Amino Acid Analyses Introduction Manual", Spinco Division, Palo Alto, Calif., 1972.
Birecka, H., Catalfamo, J., Urban, P., *Plant Physiol.*, **57**, 74 (1976).
Birecka, H., Catalfamo, J., Urban, P., *Plant Physiol.* **55**, 611 (1975).
Bøg-Hansen, T. C., Larsson, O. M., Ory, R. L., *Biosynthesis* **5**, 334 (1974).
Bomben, J. L., Dietrich, W. C., Sanshuck, D. W., *J. Food Sci.* **38**, 590 (1973).
Bottcher, H., *Nahrung* **19**, 1973 (1975).
Bruemmer, J. H., Roe, B., Bowen, E. R., Buslig, B., *J. Food Sci.* **41** 186 (1976).
Cherry, J. P., Ory, R. L., Plant Phosphatases, USDA Southern Regional Research Center, unpublished data, 1977.
Combs, O. B., Wade, E. K., Libby, J. L. *Wis. Univ. Coop. Exten. Progr.* Fact Sheet A 2360 (1973).
Constantin, R. J., Fontenot, J. E., Barrios, E. P., *J. Am. Soc. Hortic. Sci.* **99**, 505 (1974).
Dumonthay, J., *Rev. Hortic. Suisse* **9**, 88 (1936).
Fiske, C. H., Subbarow, Y., *J. Biol. Chem.* **66**, 375 (1925).
Flick, G. J., Jr., Ory, R. L., St. Angelo, A. J., *J. Agric. Food Chem.* **25**, 117 (1977).
Gardner, H. W., Inglett, G. E., Anderson, R. A., *Cereal Chem.* **46**, 626 (1969).
Gaspar, T., Bouchet, M. *Experientia* **29**, 1212 (1973).
Gorin, N., Heidema, F. T., *J. Agric. Food Chem.* **24**, 200 (1976).
Grossman, S., Trop, M., Autalion, R., Pinsky, A. *Lipids* **7**, 467 (1972).
Haard, N. F., Sharma, S. C., Wolfe, R., Frenkel, C., *J. Food Sci.* **39**, 452 (1974).
Haard, N. F., Timbie, R., *J. Food Sci.* **38**, 642 (1973).
Hatanaka, A., Harada, T., *Agric. Biol. Chem.* **36**, 2033 (1972).
Jaiswal, S. P., Kaur, G., Bindra, U., Singh, J. *Indian Food Packer* **28**, 10 (1974).
Knapp, F. W., *Proc. Fla. State Hortic. Soc.* **74**, 256 (1961).
Leveille, G. A., Bedford, C. L., Kraut, C. W., Lee, V. C., *Fed. Proc., Fed. Am. Soc. Exp. Biol.* **33**, 2264 (1974).
Lehninger, A. L., "Biochemistry", Worth Publishers, Inc., New York, N.Y., 1975.
Mishra, G. M., *Sci. Cult.* **32**, 545 (1966).
Munsell, H. E., Williams, L. O., Guild, L. P., Troescher, C. B., Harris, R. S., *Nicaragua Food Res.* **15**, 355 (1950).
Ornstein, L., Davis, B. H., *Ann. N.Y. Acad. Sci* **121**, 321 (1964).
Ory, R. L., Henningsen, K. W., *Plant Physiol.* **44**, 1488 (1969).
Patnik, B. P., *Indian Hortic.* **11**, 30 (1967).
Pinsky, A., Grossman, S., Trop, M., *J. Food Sci.* **36**, 571 (1971).
Popushoi, I. S., Shteinberg, M. E., and Kharkova, A. P., *Isu. Akad. Nauk. Mold. SRR, Ser. Khim* Nauk. **6**, 55 (1973); *Chem. Abstr.* **81**, 10193.
Rhoades, J. L., Chen, T. T-L., *Proc. La. Acad. Sci.* **31**, 121 (1968).
Sacher, J. A., *Plant Physiol.* **55**, 382 (1975).
Scandalios, J. G., *Biochem. Genet.* **3**, 37 (1969).
Seevers, P. M., Daly, J. M., Catedral, F. F., *Plant Physiol.* **48**, 353 (1971).
Sherman, W. C., *Food Nutr. News* **46**, 3 (1974).
Singh, D., *Curr. Sci.* **34**, 696 (1965).
Singh, R., Singh, J., Nandpuri, K. S., *Indian J. Hortic.* **31**, 242 (1974).
Spackman, D. H., Stein, W. H., Moore, S., *Anal. Chem.* **30**, 1190 (1958).
St. Angelo, A. J., Dupuy, H. P., Ory, R. L., *Lipids* **7**, 793 (1972).
St. Angelo, A. J., Ory, R. L., Symposium: Seed Proteins, Proceedings, 1971, 285 (1972).
Tao, K. L., Khan, A. A., *Plant Physiol.* **57**, 1 (1976).
Tiebout, G. L., La. State Univ. Agric. Mech. Coll. Extension Circ. 211, Baton Rouge, La., 1914.
Vetter, J. L., Nelson, A. I., Steinberg, M. P., *Food Technol.* **12**, 244, (1958).
Viraktamath, G. S., Adadaswamy, B., Subba Rao, K. R., Suryanarayana, B. N., Iyengar, N. V. R., Srivastana, H. C., *J. Food Sci. Technol.* **12**, 326 (1963).
Whitaker, T. W., Davis, G. N., "Cucurbits", Interscience, New York, N.Y., 1962.
Wood, J. R., *Physiol. Plant Pathol.* **1**, 133 (1971).
Worthington, "Enzyme Manual", Worthington Biochemical Corp., Freehold, N.J., 1972, pp 1–2, 39–42.
Yoshimura, K., *J. Biochem. (Tokyo)* **1**, 347 (1922).

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