Changes in the Chemical Composition of Eggplant Fruits during Development and Ripening

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Changes in the chemical composition of eggplant were studied during development and ripening of the fruits. The study was carried out on three cultivars of eggplant. Eggplant fruit was analyzed at six developmental stages for chemical composition, titratable acidity, reducing and total sugars, ascorbic acid, proteins, and total phenols. These constituents are responsible for typical sensorial and flavor characteristics of fruits. All increased during development to a maximum value at 42 days after fruit set. Few differences were found among the cultivars studied.

INTRODUCTION

Eggplant is of tropical origin and produces fruits with many different shapes, depending on the cultivar; the size of the fully developed fruit varies over a wide range, from a few grams or centimeters to more than 1 kg or 60 cm in length (Nothmann, 1986).

Natural fruit set in the eggplant depends on the morphology of the flower, its position in the cluster, and environmental factors.

Eggplant fruits for human consumption are harvested when they are physiologically unripe, long before they reach their final size, texture, and color, like cucumbers and winter squash.

During development and ripening a succession of basic reactions of synthesis and degradation of the main fruit's components is produced (Rhodes, 1983).

In the present paper we have reported data with respect to acidity, sugars, ascorbic acid, protein, and total phenols. Studies on the chemical composition in eggplant fruits during development and ripening are not reported in the literature. Because of the scant information available about the chemical composition of the various varieties, it was considered desirable to ascertain the changes in their composition, information that might be of use to consumers and food technologists.

MATERIALS AND METHODS

Eggplant fruits (*Solanum melongena* L.) obtained from a hydroponic culture were used for this study. The hydroponic cultures were grown in a greenhouse controlled by a minicomputer. Constant concentration of nutrient solutions was attained by a pumping flow method. The experimental design was a randomized block system with three replications. Samples of three different cultivars (Semi-round Striped, SS; Purple Long, PL; and Black Round, BR) were harvested at various development stages (5, 11, 15, 28, 42, and 54 days after fruit set). Table I shows the sizes and weights corresponding to each cultivar and sampling date. Determinations were made on fruits from 12 plants of each cultivar. On each sampling day, fruits of the same size and color were selected. These fruits were peeled and chopped before the analytical determinations.

Acidity. Fruit samples were homogenized to obtain the pH and titratable acidity values; the pH was measured with a common pH meter, and titratable acidity was determined with 0.1 N NaOH up to pH 8.1.

Sugars. Ten-gram samples of fruit were extracted with 200 mL of 80% ethanol by stirring for 3.5 h. Reducing sugars were determined according to the Bittner–Manning (1967) method using a Technicon autoanalyzer. Total sugars were determined by previous acid hydrolysis of the sugar extract.

Table I. Weights and Sizes Expressed in Length and Diameter of the Fruit for Each Sampling Period

		days after fruit set					
	cultivar	5	11	15	28	42	54
wt, g	SS	11	25.9	51.3	214.9	390.6	446
	PL	13	46.0	86.5	154.2	216.6	217.4
	BR	14.1	48.4	74.5	364.6	479.9	584.7
length, cm	SS	2.5	5.3	7.5	13.4	15.3	17.5
	PL	4.6	6.6	10.3	18.3	20.8	23.6
	BR	3.7	6.1	6.3	13.7	15.2	18.7
diameter, cm	SS	1.7	3.3	4.1	6.9	7.5	8.1
	PL	2.4	3.9	4.1	5.3	5.3	5.5
	BR	2.8	3.8	4.2	7.8	9.7	12.4

Ascorbic Acid. Determination was carried out with 2,6-dichlorophenolindophenol (Association of Official Analytical Chemists, 1975).

Proteins. The extraction was performed on 10 g of fruits with 50 mL of 0.05 N NaOH, followed by precipitation with sulfosalicylic acid and redissolution of the protein precipitate. This minimized interference in protein determination by the automatized Lowry method (Gaunce and D'Iorio, 1970).

Total Phenols. Twenty-five grams of each sample was put into a 100-mL flask equipped with a reflux condenser, and 100 mL of boiling methanol was poured in and is boiled for 5 min to stop enzymatic activity. After being homogenized, the mixture was again transferred to a flask for extraction and reflux during 1 h. Determinations were made according to the Folin–Ciocalteu method (Singleton and Rossi, 1965), which is a global evaluation of polyphenols. The standard used was gallic acid.

Statistical Analysis. All determinations were carried out in triplicate. The results are expressed in fresh matter, except for ascorbic acid (per fruit). Least significant differences (LSD) for cultivars and samplings were calculated using an analysis of variance with significances of 1 and 5% (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

Figure 1 shows the variations observed in fruit pH. For the three varieties studied, there is a trend of fairly rapid increase between days 5 and 15. From this point, the Semi-round Striped variety decreases slightly until 42 days, at which time it rapidly declines. The Black Round variety shows a marked decrease until 28 days, and thereafter the pH value diminishes more slowly. The other variety shows an intermediate trend. Titratable acidity has been expressed as malic acid because it is the major acid (Kozukue et al., 1978). Fruit titratable acidity (Figure 2) initially decreased sharply in the first stages followed by a continuous and gentle increase.

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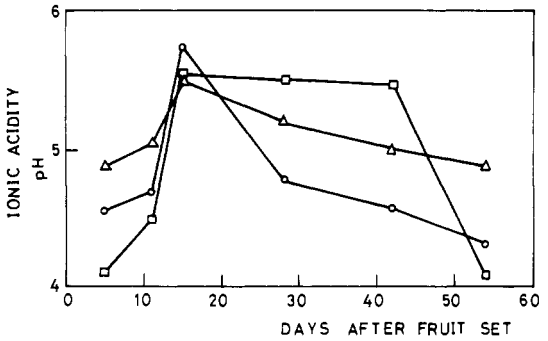

Figure 1. Changes in ionic acidity during development and ripening of fruits. (O) Black Round; (△) Purple Long; (□) Semi-round Striped.

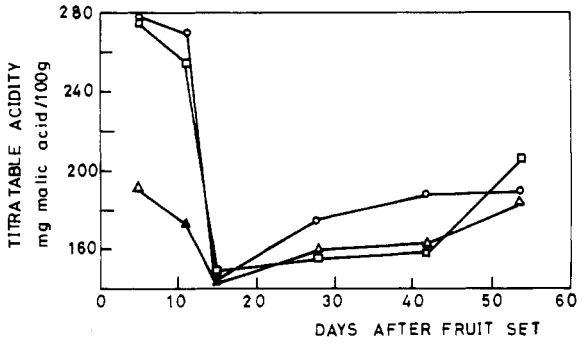

Figure 2. Changes in titratable acidity during development and ripening of fruits. (O) Black Round; (△) Purple Long; (□) Semi-round Striped.

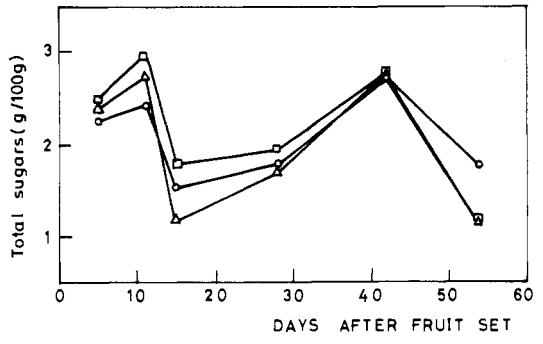

Figure 3. Changes in total sugars during development and ripening of fruits. (O) Black Round; (△) Purple Long; (□) Semi-round Striped.

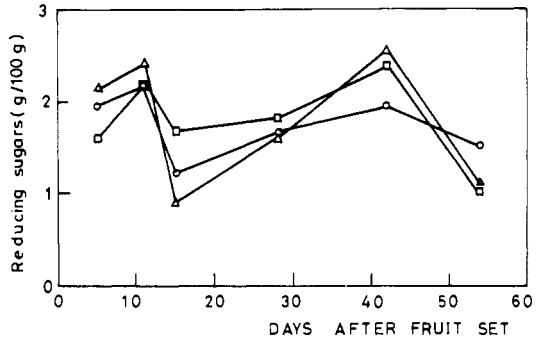

Figure 4. Changes in reducing sugars during development and ripening of fruits. (O) Black Round; (△) Purple Long; (□) Semi-round Striped.

Figures 3 and 4 show the results obtained for total and reducing sugars, respectively. The sugar content in eggplant fruit is mainly constituted by reducing sugars. These results are in agreement with those of Kozukue et al. (1978), who indicate glucose and fructose as the major sugar fractions. Nevertheless, the lack of nonreducing

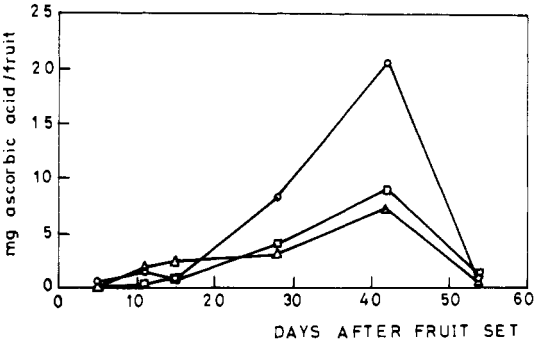

Figure 5. Changes in ascorbic acid during development and ripening of fruits. (O) Black Round; (△) Purple Long; (□) Semi-round Striped.

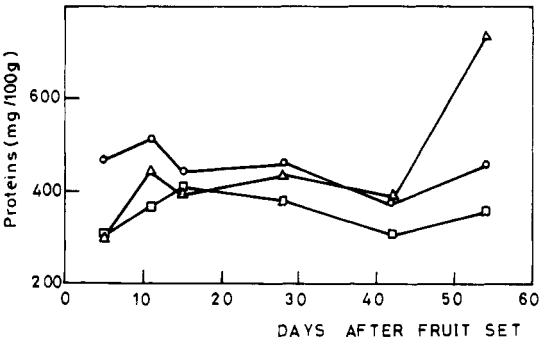

Figure 6. Changes in proteins during development and ripening of fruits. (O) Black Round; (△) Purple Long; (□) Semi-round Striped.

sugars in our case may be due to the presence of invertase enzyme, which was not inactivated during extraction steps. In many fruits, the sugar content presents a considerable increase during development (Whiting, 1970), including eggplant fruit (Nothmann, 1986) which shows an increase for some weeks and somewhat decreases later. The results obtained in this experiment (Figures 3 and 4) emphasize the peculiar physiology of eggplant fruits: There is observed a sugar accumulation in the first days of development, but later on the fruit begins an intense growing phase with resultant sugar consumption. When the developing fruit surpasses this phase, sugars are again accumulated until the 42nd day. At 6 weeks from fruit set there is a maximum of sugars, and the fruits reach their sensorial plenitude. After that, the sugar content decreases, producing fruits of lower commercial quality. Moreover, the acidity/sugars ratio remains at 0.1 until the 42nd day, at which time it diminishes to 0.06.

The results for ascorbic acid are shown in Figure 5. Its content is expressed in milligrams per fruit, since if it were expressed in milligrams per 100 g of fresh weight the evolution would be clearly affected by the intense development in some phases. A parallelism is observed between the evolution of this vitamin and that of sugars. Both components increase until the 42nd day and decrease later on. The decreases that were observed in the last days confirm a protecting role of ascorbic acid against other structures of the fruit according to the findings of Mapson (1970).

The protein content (Figure 6), expressed in milligrams per 100 g of fresh weight, remains almost invariable during the first 42 days, presenting a steady accumulation, a doubling in some cultivars, later. Therefore, in this stage, a synthesis of protein seems to be occurring, which has been observed in other fruits such as tomato and apple, and has been reported by various authors as a synthesis de novo (Tucker and Grierson, 1982; Lurie and Ben-Arie,

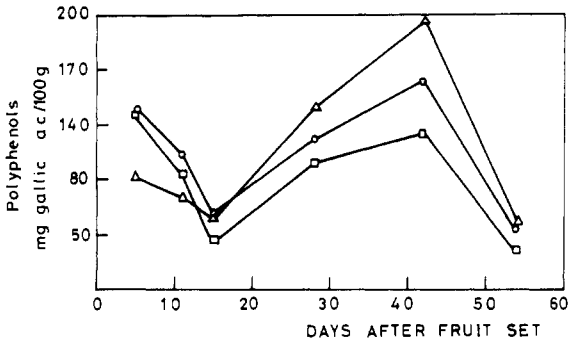

Figure 7. Changes in total polyphenols during development and ripening of fruits. (○) Black Round; (△) Purple Long; (□) Semi-round Striped.

1983). In this way, the Semi-round Striped cultivar presents significative minor values.

Total phenols (Figure 7) in the Semi-round Striped cultivar show significative differences from that of the other cultivars. There is an accumulation of these compounds during development. The maximum which coincides with that of sugars, ascorbic acid (Figures 3–5), and chlorophylls (Mollá et al., 1990), indicates a maximum color intensity at the 42nd day from fruit set, diminishing after that time.

CONCLUSION

The fact that substances responsible for the flavor, vitaminic, and sensorial characteristics of the fruit, such as sugars, ascorbic acid, and polyphenols, reached their maximum values near the 42nd day from fruit set emphasizes the importance of this inflection point in the development and ripening of the fruit. We consider the physiological maturation of the fruit to be reached at this stage.

In the comparison of the three cultivars studied, we have not found great differences among them.

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