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ASCORBIC ACID, PIGMENTS AND MINERAL ELEMENT CONTENTS ASSOCIATED WITH GROWTH AND DEVELOPMENT OF PIMIENTO PEPPER

FOUAD M. BASIOUNY AND P. K. BISWAS
Plant and Soil Sciences, Department of Agricultural, Sciences, Tuskegee Institute, Tuskegee, AL 36088

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Abstract. **Changes in ascorbic acid, chlorophyll, carotenoid, anthocyanin, and mineral element contents of pimiento pepper** (Capsicum annuum **L.) during growth and development were studied. The greenhouse-grown fruits showed gradual decrease in chlorophyll contents during the growing season. Ascorbic acid, carotenoids and anthocyanins increased as fruits advanced in ripening. The stage of fruit growth and development in relation to fruit ripening, levels of ascorbic acid and mineral elements content was discussed.**

Pimiento peppers are grown commercially in more than 14 countries and a large number of states in the U. S. The principal areas of production for pimiento peppers are Georgia, South Carolina, Alabama, Tennessee and California (2). The first pimiento pepper cultivar grown in the U. S. was introduced from Spain in 1911 (5). Pimiento pepper is a sweet, large, pointed, heart-shaped fruit which has a distinctive aromatic flavor. They must be fully red to be acceptable for processing and desirable for their decorative color and the flavor they impart to processed food. The consumers prefer a red fruit in a ready-to-eat stage with an attractive appearance, a crisp texture and have a flavor which is true to the fruit and the specific variety (3, 7). The stage of maturity or ripening at the time of harvest must be such that the fruits attain their high organoleptic properties, fully grown, firm, possessing high degree of handling ability, keeping quality and nutritive value. Flowering and fruiting habits of the plants, environmental conditions, market location and population distribution sometimes force the pepper growers to harvest the fruits at different stages of maturity and ripening. The purpose of this research was to study the trends in ascorbic acid, chlorophyll, carotenoid, anthocyanin and mineral element contents in pimiento pepper fruits at different stages of growth and development.

Materials and Methods

Forty-eight 'Bighart' pimiento pepper (*Capsicum annuum* L.) plant growing under greenhouse conditions were used for this study. They were planted in 15 cm plastic pots in an unfertilized medium of equal parts peat-moss, vermiculite and sand. The plants received basic nutrients solution which was made up according to Hoagland and Arnon (6) except for Fe which was added as FeEDTA (ethylenediaminetetraacetic acid) (Ciba-Geigy Co., Ardsley, NY) at a rate of 10 ppm. Beginning of anthesis, four stages of blooms, four flowers in each plant were tagged to secure fruits at the same stage of growth and development. Four harvests were made at approximately 2 week intervals starting October, and ending December, 1980. The first harvest was made when the fruits were at mature green stage (mature green stage). The second harvest was made at the color break stage (color break stage). Fruits of the third harvest were picked at the full red (red stage). For the fourth harvest the fruits were picked when they were overripe (overripe stage). At each harvest, samples consisting of at least 25 fruits of the same stage of growth were collected. Fruits were taken to the laboratory for analyses. Ascorbic acid analyses were made by 2,6-dichlorophenolindophenol method (11) in a 100 g. composite sample of fresh fruit tissue. Chlorophyll was extracted with 80% acetone and determined by Arnon's modification (1) of Mackinney's method (8). Total carotenoid were extracted with acetone and transferred to petroleum ether, washed with water and 1% Na_2SO_4. The dried solution was evaporated under vacuum and made up to a definite volume with ethyl ether (11). Absorbance of the solution was measured at 458 mμ using a Hitachi grating spectrophotometer. Anthocyanin pigments were extracted by a modification of the procedure described by Dekozos and Worley (4). The total anthocyanin content was calculated and based on the molar-extinction coefficient for Idaein at 530 mμ (12). P, K, Mg and Fe analyses were carried out by atomic absorption spectrophotometer.

Results and Discussions

Ascorbic Acid Content

As pimiento fruits ripened, the milligrams of ascorbic acid per 100 g. of tissue increased (Table 1). The highest amounts of ascorbic acid were found in fruits harvested at the overripe stage. There was approximately 26% increase in ascorbic content in fruits harvested at this stage than those harvested while green. The data agreed with these obtained by Matthews and Locascio (9) using 'Yolo Wonder L.' Fruits at color break stage was intermediated in their ascrobic acid contents. The lowest values of ascorbic acid was found early in the season at the mature green stage.

Table 1. Changes in ascorbic acid, and chlorophyll contents during growth and development of pimiento pepper fruits.[z]

Harvest Stage	Ascorbic acid mg/100 g. fr. wt.	Total chlorophyll mg/g. fr. wt.
Green	128.7 a	4.46 a
Color break	137.0 b	4.21 b
Red	141.3 c	3.02 c
Overripe	162.1 d	1.09 d

[z]Each figure is an average of 4 replications. Values in a Column followed by the same letter are not significantly different at the 5% level as determined by Duncan's Multiple Range Test.

In view of the importance of the ascorbic acid content in peppers in determining their dietetic value, the above data is of particular interest. It is well known that ascorbic acid is readily oxidized and this is somehow connected with the normal fruit metabolism. Based on these findings, for the consumer, red ripe or overripe fruits are more beneficial in supplying the recommended daily allowance of ascorbic acid than fruits at the color break or mature green stage.

Chlorophyll Content

There was a general downward trend in total chlorophyll in pimiento pepper fruits as they advanced in ripening from October through December 1980 (Table 1). Chlorophyll decreased slowly in fruits harvested at the early green stage.

Red color began to develop around the 1st of November and was accompanied by a rapid decrease in total chlorophyll which could be due to the natural degradation of chlorophyll synthesis or the activity of certain enzyme systems such as chlorophyllase. Despite the fact that the fruits were totally red at the 4th harvest, considerable amounts of chlorophyll remained in the fruits which were masked by the other dominating plant pigments.

Carotenoids Content

Data in Table 2 indicate a gradual increase in ether—soluble carotenoid content of pimiento pepper fruits as they developed from the green to the overripe stage. The slightly reddish yellow color started to increase in the plants before chlorophyll had disappeared. There was an inverse relationship between the decrease in total chlorophyll and the increase in total carotenoid. However, the rate of the decrease in total chlorophyll was not equal to the rate of increase in carotenoid contents. Carotenoids accumulated in a relatively higher rate in the red-stage or overriped fruits than the decrease in total chlorophyll in the same fruits. This is of significance to both the grower and the consumer since carotenes and cryptoxanthin, which are considered members of the carotenoid group, are precursors of vitamin A, an important vitamin in pepper fruits and necessary for human nutrition.

Table 2. Changes in caratenoid and anthocyanin pigments during growth and development of pimiento pepper fruits.[z]

Harvest Stage	Total carotenoid mg/100 g. fr. wt.	Total anthocyanin mg/50 g. fr. wt.
Green	0.301 a	9.2 a
Color break	0.393 b	12.7 b
Red	0.442 b	14.8 c
Overripe	0.447 c	19.1 d

[z]Each figure is an average of 4 replications. Values in a Column followed by the same letter are not significantly different at the 5% level as determined by Duncan's Multiple Range Test.

Anthocyanin Content

Anthocyanin content increased in pimiento fruits as they ripened (Table 2. Anthocyanins increased approx 107% in the pepper fruits harvested at overripe stage as compared with similar fruits harvested at the green stage. Despite the fact that anthocyanins are present in pepper fruits as glycosides containing most commonly, one or two glucose or galactose units attached to one of their hydroxyl groups, they are considered by-products of plant metabolism and their nutritive value is questionable. However, their high content which occurred in red or overripe fruits may be desirable in processing to improve the flavor of the canned products.

Mineral Element Contents

Changes in mineral element contents in pimiento pepper beginning of October 1st through December 30, is shown in Table 3. With the exception of Fe, which fluctuated in the fruits at the various stage of development, each of Ca, K, and P accumulated in the fruit as it advanced in ripening. Ca content increased significantly only as the fruits advanced from the green to the color break stage. K, on the other hand, showed a steady increase at each stage of fruit development. Red ripe fruits contained significantly more K than mature green fruits. Fruits harvested at the overripe stage at the end of December had about 18% more P than fruits at the green stage which was harvested early in October.

Table 3. Changes in mineral element contents during growth and development of pimiento pepper fruits.[z]

Harvest Stage	Ca	K	P	Fe
	mg/100 g. fr. wt.			
Green	9 a	160 a	23 a	.4 a
Color break	13 b	162 a	25 a	.3 a
Red	12 b	175 b	25 a	.5 a
Overripe	12 b	173 b	28 b	.3 a

[z]Each figure is an average of 4 replications. Values in a Column followed by the same letter are not significantly different at the 5% level as determined by Duncan's Multiple Range Test.

Considering the nutritive value of the fruit one can generalize that fruits at the red stage contain more mineral elements than at earlier stages of growth and development.

The relation of these findings to the maturity and ripening of pepper fruits is of particular importance to the consumer. By definition maturity refers to the stage of fruit development. A mature pepper fruit then is one that has attained a stage of development that it will ripen with acceptable eating quality. Ripening, on the other hand, refers to the processes which quantitatively transform the mature fruit. These processes include softening of the flesh, hydroletic conversion of storage materials and changes in pigments and flavor (10). Since the ripening processes of pepper fruits can occur only while they are attached to the mother plant, it is obvious that they should not be harvested until they are mature and hence ripe. Based on our findings of this report, green pimiento pepper fruits were high only in chlorophyll content, while red ripe fruits, though they contained reasonable amounts of the green pigments, they were high in carotenoid, anthocyanin and mineral element contents. It is recommended therefore that for the highest quality, nutritive value, and eye appealing characteriestics, fruits should be harvested when they are fully red.

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