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Ascorbic Acid, Riboflavin, and Thiamine Content of Sweet Peppers during Marketing

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Abstract. **Sweet peppers from wholesale and retail markets and simulated consumer storage were analyzed for total ascorbic acid, riboflavin, and thiamine. Peppers from these tests contained an overall average of 117 mg ascorbic acid/100 g freshweight (gfw), 49 μg riboflavin/100 gfw and 65 μg thiamine per 100 gfw. Among sampling dates ascorbic acid (AA) levels differed significantly, but levels of riboflavin and thiamine did not. The range of variation of the mean concentration of total AA, riboflavin, and thiamine for all marketing levels were 3.4%, 36%, and 11%, respectively. None of these variations among marketing levels, however, was statistically significant. This study supports the hypothesis that average concentrations of vitamins do not change significantly from wholesale marketing to consumption, but significant variations do occur among individual market samples.**

Sweet peppers are ranked 4th in ascorbic acid and 16th in riboflavin and thiamine among 42 fruit and vegetables ranked for vitamin content (13). Peppers can be found throughout the year in retail stores and are increasing in popularity. From 1970 to 1977, per capita consumption increased 150% (16).

Temperatures of 7.2° to 10.0°C and relative humidities of 90% to 95% are recommended for storage and transportation of peppers (2, 8, 10, 11). Under optimum conditions, peppers can be stored for 2 to 3 weeks after harvest. Quality values of peppers can change as the crop is harvested and as it undergoes different handling, storage, and transportation conditions enroute to the various markets. The vitamin content could change, however, because marketing conditions for peppers are usually suboptimal. Cappellini (4) reported no differences in ascorbic acid (AA) content of peppers during short-term storage at temperatures above and below the chilling threshold (7.2°C) in modified atmospheres. Wang (17) reported that AA content of peppers increased with storage at 13°C and with subsequent ripening at 20°C.

This research was conducted to determine by semiautomated microfluorometic technique the content of AA, riboflavin, and thiamine in sweet peppers at wholesale and retail markets and after simulated consumer storage. The tests were designed to analyze commercial peppers during actual marketing conditions.

Peppers shipped from at least 2 southern states and 1 western state to wholesale and retail markets in the greater New York area were used in these tests. Portions of retail samples were stored 3 days at 5.5°C to simulate consumer storage. Beginning in Sept. 1980 samples were taken biweekly. From 1980 to 1982, 252 samples of peppers were collected for analysis of total AA, 72 samples for analysis of riboflavin, and 54 samples for analysis of thiamine. From each crate we purchased at wholesale, we selected at random 6 samples of 5 peppers.

Our retail and "stored' samples were purchased from 6 different stores and consisted of 10 peppers per sample. Five peppers from each sample were analyzed immediately (retail) and 5 were analyzed after 3 days storage at 5.5°C (stored). Half of each pepper then was finely chopped and the chopped pieces from the 5 peppers of each sample were combined for extraction.

The experimental design was a randomized complete block; blocks were times of sampling and treatments were marketing levels. There were 14 times of sampling for AA, 4 for riboflavin, and 3 for thiamine. Significance of differences was determined by analysis of variance multiple range test and SE of the means (3, 6, 14).

A continuous flow Technicon Autoanalyzer II (Technicon Industrial Systems, Tarrytown, NY 10591) was used to analyze the peppers for total AA, riboflavin, and thiamine (5, 9, 12, 15). The proper optical filters to excite and measure fluorescence of each vitamin were inserted into the fluoronephelometer. For the analysis of total AA, 10 g of chopped peppers were placed in a blender at 20500 rpm for 3 min with 200 ml of 0.5% oxalic acid, and filtered through Whatman 1 filter paper into amber volumetric flasks. Amber flasks were used to prevent light degradation of some of the vitamins. N-bromosuccinimide converted the reduced AA to dehydroascorbic acid (DHAA); orthophenylenediamine dihydrochloride (OPDA) caused the DHAA to fluoresce at 435 nm after excitation at 365 nm. Parallel samples of the extracted mixtures were run in the presence of sodium borate to obtain a blank correction. Borate complexed the DHAA so that it did not react with OPDA. Known standards were run with the samples for each vitamin. The resulting values were used to calculate the vitamin content of the samples.

For the analysis of riboflavin, 20 g of chopped peppers were autoclaved for 30 min at 121°C with 100 ml of 0.1 M HCl, then adjusted to pH 4.3 with 1.25 M sodium acetate. Fifty milliliters were brought to 100 ml with pH 4.3 metaphosphoric acid and filtered through Whatman 2V filter paper. Fluorescence was excited at 436 nm and measured at 510 nm. The method (5) required us to measure fluorescence of riboflavin in an acidic medium to destroy interfering substances by oxidation with K permanganate, and to decolorize the permanaganate with sodium bisulfite. Any interfering residual fluorescing materials present in the dialyzate were measured separately after reducing the riboflavin with sodium hydrosulfite.

Table 1. Vitamin content per 100 g freshweight of green pepper at 3 marketing levels (wholesale, retail, and simulated consumer storage).

Vitamin	Overall mean value	SD	Marketing level	Mean value	Minimum value	Maximum value
Ascorbic acid	117 mg	8mg	Wholesale	119 mg a	70 mg	165 mg
			Retail	118 mg a	60 mg	197 mg
			Stored	114 mg a	35 mg	162 mg
Riboflavin	48 μg	26 μg	Wholesale	37 μg a	12 μg	86 μg
			Retail	58 μg a	27 μg	90 μg
			Stored	49 μg a	12 μg	86 μg
Thiamine	65 μg	7 μg	Wholesale	65 μg a	52 μg	101 μg
			Retail	58 μg a	39 μg	75 μg
			Stored	68 μg a	56 μg	99 μg

[z]Means separation by Duncan's multiple range test (5% level) for wholesale, retail and stored peppers were grouped and statistically analyzed by vitamin.

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Table 2. Analysis of variance of the content of ascorbic acid, riboflavin, and thiamine in peppers based on time of sampling and marketing level (wholesale, retail, and stored).

Vitamin and source of variation	df	Mean square	F
Ascorbic acid			
Time of sampling	13	296.69	11.87 **[z]
Marketing levels	2	69.46	2.78 NS
Error	26	24.99	
Riboflavin			
Time of sampling	3	1756.78	4.82 *
Marketing levels	2	439.75	1.21 NS
Error	6	364.53	
Thiamine			
Time of sampling	2	82.34	3.63 NS
Marketing levels	2	101.34	4.47 NS
Error	4	22.67	

[z]*,**Significant at 5% and 1% levels, respectively.

We used a modification of the Kirk and Technicon methods (9, 15) for thiamine analysis. The samples (10 g) were extracted with 100 ml of 0.1 M HCl, blended 3 min at 20500 rpm in a microblender, autoclaved 30 min at 121°C, adjusted to pH 4.3 and brought to 100 ml with pH 4.3 metaphosphoric acid. Potassium ferricyanide oxidized the thiamine in the filtrate to thiochrome, which fluoresces in ultraviolet light at 435 nm after excitation at 365 nm. Parallel samples were run with distilled water replacing K ferricyanide to obtain a blank correction.

Over the 3-year period of testing, 252 samples of peppers contained an average of 117 mg total AA/100 gfw, 72 samples contained an average of 48 μg riboflavin/100 gfw and 54 samples contained an average of 65 μg thiamine/100 gfw (Table 1). The total AA was 11 mg/100 gfw less than reported by Adams in a consumer nutrition study (1) and 43 mg/100 gfw less than reported by Howard et al. (7) in fresh California-grown peppers. Minimum and maximum values from individual wholesale, retail, and stored pepper samples varied by as much as 95, 137, and 127 mg, respectively. The mean AA contents at wholesale, retail and consumer marketing levels, however, varied by only 3.4%. Differences among marketing levels were not significant (Table 2). There was great variability in AA among samples during the 3-year sampling period. Season, year, growing area, and fruit maturity must account for some of these differences in AA content between times of sampling. There were observable differences in the maturity, color, flesh thickness, and firmness of peppers sampled from various growing areas. Quality at wholesale and retail markets also varied. Some samples were unbruised, dark green and turgid with no decay, others were flaccid, bruised and poorly-colored with varying amount of decay. Nevertheless, no consistent variation in AA could be associated with any of these factors including year, season, or point of origin.

The riboflavin content of peppers was 40% less than reported by Adams (1), and 2.4 times more than reported by Howard et al. (7). Minimum and maximum riboflavin values from individual wholesale, retail, and stored samples varied by 74, 63, and 74 μg, respectively. The mean riboflavin contents of wholesale, retail, and stored peppers varied by 21 μg/100 gfw. The differences in riboflavin were neither significant among the times of sampling nor among marketing levels.

Minimum and maximum thiamine values from individual wholesale, retail, and stored samples varied by 49, 36, and 43 μg, respectively. However, the mean thiamine content of wholesale, retail, and stored peppers varied by 10 μg/100 gfw. The differences in thiamine content among times of sampling and marketing levels were not significant.

This study supports the hypothesis that average concentrations of vitamins do not change significantly in peppers from the wholesale level of marketing to consumption. Significant variations do occur, however, among individual market samples. The consumer, therefore, cannot assume that standared values of a particular vitamin exist in a specific horticultural sample.

The samples analyzed for this study were purchased in eastern terminal markets 6 to 12 days after harvest. Thus, because of necessary restraints in the experimental design, we have no direct information on vitamin contents at the time of harvest. Comparisons of our data, however, with published values for freshly-harvested peppers (7) suggest that there is a loss in AA content between harvest and arrival at the terminal markets. Comparison of data on thiamine (1) also suggests a comparable loss. There is a need, therefore, to resolve these questions and investigate the relationship of horticultural quality and vitamin content during the critical period between harvest and arrival at marketing channels.

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