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ABSTRACT

A study was conducted to determine the alpha- and beta-carotene content of supermarket vs roadside stand produce using high performance liquid chromatography (HPLC). The fruits and vegetables were obtained from a major local supermarket chain (Doug's Shop'n Save, Bangor Mall, Bangor, ME) and three roadside stands in Dixmont, Etna and Charleston, ME. Thirteen vegetables and one fruit were sampled during a ten week period between July and September of 1985. Significant differences at the 0.05 level were observed between supermarket and roadside stand produce for only Swiss chard and green peppers with roadside stands having higher beta-carotene levels in both instances. Alpha-carotene was shown to be non significant among sources at the 0.05 level in all cases.

INTRODUCTION

As researchers learn more about the relationship of dietary intake and human health, an accurate and specific assessment of the nutrient content of foods is becoming more important. One such group of nutrients is the provitamin A carotenoids which are comprised of approximately 18 compounds (13,14) varying in vitamin A activity and with the most prevalent and active ones found in the common raw fruits and vegetables being alpha- and beta-carotene. Beta-cryptoxanthin and gamma-carotene possess vitamin A activity, but are found in most foods at a low concentration (except for beta-cryptoxanthin in peaches, oranges and sweet corn). Besides their normal vitamin A function, recent research has shown that some provitamin A compounds have anticancer, antiaging and antiulcer properties (1,3-4, 8-11,16).

Antineoplastic evidence has been of two types. First, epidemiological studies have shown the existence of an inverse relationship between the risk of cancer and the consumption of foods containing beta-carotene (8-10, 1,3,11). Second, several laboratory experiments have demonstrated the inhibition of cancer cell lines and actual tumor regression in animals given beta-carotene (8,10,16).

Antiulcer properties were observed by Mozsik et al. (9). They were able to show that beta-carotene and beta-cryptoxanthin were involved in preventing cellular damage from acid in the gastric mucosa.

Antiaging effects of carotenoids were demonstrated by Cutler (4). He was able to show that a positive correlation exists between the concentration of carotenoids in serum and brain tissue and the maximal life span potential of mammalian species.

Furthermore, it is widely known that food composition tables are invaluable tools for nutritionists when planning and evaluating diets and establishing dietary guidelines (6) and for epidemiologists in studying the relationship of nutrients to disease. To date, the tables used for fruits and vegetables are usually ones like the U.S. Department of Agriculture's Handbook No. 8 (15) or revised Handbook No. 8-9 (5), neither of which includes individual carotenoid values. Also, the methods employed for obtaining the vitamin A values in these tables, are for the most part, not the current analytical procedures. The purpose of this study was to employ modern analytical technology (HPLC) to quantify individually and totally the carotenoids, alpha- and beta-carotene, in 14 produce items obtained from roadside stands and supermarkets.

MATERIALS AND METHODS

Trans alpha-carotene was obtained from Sigma Chemical Co., St. Louis, MO while trans beta-carotene was purchased from Fluka Chemical Corp., Hauppauge, NY. Stabilized tetrahydrofuran (THF) was bought from VWR Scientific, Bridgeport, NJ while the acetonitrile and methanol, all HPLC grade, were obtained from Fisher Scientific Co., Fair Lawn, NJ.

Fruit and vegetable samples were obtained from four locations in Maine Etna, Dixmont, Charleston and Bangor. The samples from Bangor came from Doug's Shop'n Save in the Bangor Mall while the other samples came from roadside stands. Samples were collected for a period of ten weeks from July to September and consisted of carrots, peas, cantaloupe, beet greens, broccoli, Swiss chard, green onions, green beans, green peppers, buttercup squash, Brussels sprouts, red and yellow tomatoes and corn. Roadside stands were sampled every Thursday morning while the supermarket samples were taken every Friday morning. Three pound samples were obtained and split into 3 equal subsamples with each subsample being analyzed.

All subsamples were extracted and analyzed for alpha- and beta-carotene using the HPLC procedure of Bushway (2).

The design of this experiment was Nested Anovas with unequal sample sizes. This provides the precision required by maximizing the degree of freedom and minimizing the F-value required for statistical significance (7,12). The data were analyzed using the analysis of variance method and the F-test was employed to determine the significant chemical differences among supermarket vs roadside stand. A 0.05 level of significance was used for the F-test. The data were processed by the statistical analysis system at the computer center at the University of Maine.

Alpha- and beta-carotene from every fruit and vegetable were checked for identity and purity by using absorbance ratios and visible spectra. The absorbance ratios used were 462 nm/440 nm, 455 nm/480 nm and 462 nm/470 nm while the visible scans were made from 340 nm to 500nm.

RESULTS AND DISCUSSION

The method of Bushway (2) was employed for the analysis of alpha- and beta-carotene in this study since it can efficiently separate these provitamin compounds from a variety of foods with good reproducibility, in a relatively short time and with no interferences from the cis isomers.

Confirmation of the alpha- and beta-carotene peaks for each food item was done by taking visible spectra from 340 nm to 500 nm and absorbance ratios at 3 sets of wavelengths. All the data collected on each product indicated chromatographically pure peaks and correct identity.

The vitamin A quantity of individual carotenoids (alpha- and beta-carotene) along with the sum of their vitamin A activity are given in Tables 1-16 for the supermarket vs. roadside stand produce. Tables 1-14 list the vitamin A data on each fruit and vegetable separately along with the statistical results. Table 15 shows the overall results of the alpha- and beta-carotene content of supermarket produce while Table 16 depicts the roadside stand results.

As Tables 1-14 illustrate, Swiss chard (Table 3) and green peppers (Table 12) were the only produce that demonstrated significant differences in beta-carotene content between the two types of samples. In both instances the roadside stand vegetables were higher than Doug's Shop'n Save. These tables also show that carrots (Table 1), cantaloupe (Table 2) and Swiss chard (Table 3) differ significantly in their beta-carotene content among roadside stand produce. Dixmont had the larger values for carrots and cantaloupe while Charleston's Swiss chard had the greater beta-carotene content. All other fruits and vegetables demonstrated no significant differences in the amount of beta-carotene either between roadside stand and the supermarket or among roadside stands. Furthermore, there were no significant differences in alpha-carotene content in the entire study. A comparison of yellow tomatoes results between roadside stand and supermarket could not be made since yellow tomatoes were unavailable in the supermarket. Also the analyses among roadside stands could not be done for green onions, Brussels sprouts and yellow tomatoes since these samples were present at only one stand.

Although only two foods demonstrated significant differences in favor of the roadside produce, the results given in Tables 15 and 16 show that only four items (cantaloupe, buttercup squash, green onions and Brussels sprouts) obtained from the roadside stands had lower overall average values of beta-carotene than produce from the supermarket. Thus there is a trend indicating that the majority of roadside stand produce appears to have slightly more beta-carotene. For both the roadside stand and supermarket fruits and vegetables, carrots, cantaloupe, Swiss chard and beet greens were the top four in beta-carotene value while corn was the lowest. The yellow tomatoes were also very low in beta-carotene activity and significantly lower than red tomatoes. Alpha-carotene was either low or nonexistent in most produce except for carrots, red tomatoes and supermarket broccoli.

CONCLUSION

Although the trend from the average values indicated that the roadside stand produce was generally higher in beta-carotene, only two items illustrated significant differences at the 0.05 level. Differences in alpha-carotene were shown to be non significant in all cases at the 0.05 level. Because of the lack of a large number of significant differences, one may be wise to include price as a factor in deciding where to purchase produce. Furthermore, it appears, at least for beta-carotene, that freshness does not play a major role in determining how much beta-carotene will be present as it does for vitamin C.

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Tabel 1. Vitamin A Activity and Alpha- and Beta Carotene Content of Carrots

Location	DF	Alpha-Carotene [1]	Beta-Carotene [1]	RE [2]
Supermarket (SM)		3052.80	3605.85	855.37
Dixmont (DX)		3399.32	4773.85	1078.91
Etna (ET)		2741.08	4082.68	908.87
Charleston (CH)		2420.72	2099.16	551.58
All Roadside Stands (RSS)		2957.02	4002.90	913.58
Significances				
SM vs RSS	1	NS	NS	NS
Among DX, ET, CH	2	NS	*	*

Table 2. Vitamin A Activity and Alpha- and Beta-Carotene Content of Cantaloupe

Location	DF	Alpha-Carotene [1]	Beta-Carotene [1]	RE [2]
Supermarket (SM)		69.92	2054.97	348.32
Dixmont (DX)		59.49	1873.71	317.24
Etna (ET)		40.70	609.98	105.05
Charleston (CH)				
All Roadside Stands (RSS)		54.79	1557.78	264.19
Significances				
SM vs RSS	1	NS	NS	NS
Among DX, ET, CH	1	NS	*	*

[1] Units for Alpha- and Beta-Carotene ug/100 g Sample Average Values

[2] RE = Retinol Equivalent/100 g Sample Based on Alpha- and Beta-Carotene Content Average Values

* Significant

PR>F = 0.05

NS Not Significant

No Samples

Table 3. Vitamin A Activity and Alpha- and Beta-Carotene Content of Swiss Chard

Location	DF	Alpha-Carotent[1]	Beta-Carotene[1]	RE[2]
Supermarket (SM)		34.62	2057.76	345.84
Dixmont (DX)		31.56	2993.51	501.54
Etna (ET)				
Charleston (CH)		29.73	3564.17	596.00
All Roadside Stands (RSS)		30.97	3177.59	532.18
Significances				
SM vs RSS	1	NS	*	*
Among DX, ET, CH	1	NS	*	*

Table 4. Vitamin A Activity and Alpha- and Beta-Carotene Content of Beet Greens

Location	DF	Alpha-Carotene[1]	Beta-Carotene[1]	RE[2]
Supermarket (SM)		11.06	1954.63	326.69
Dixmont (DX)		10.81	2484.86	415.04
Etna (ET)		21.39	2288.00	383.14
Charleston (CH)		16.41	2464.92	412.08
All Roadside Stands (RSS)		15.87	2428.44	406.06
Significance				
SM vs RSS	2	NS	NS	NS
Among DX, ET, CH	2	NS	NS	NS

See Table 2 for footnotes.

Table 5. Vitamin A Activity and Alpha- and Beta-Carotene Content of Buttercup Squash

Location	DF	Alpha-Carotene[1]	Beta-Carotene[1]	RE[2]
Supermarket (SM)		27.68	996.82	168.44
Dixmont (DX)		23.50	599.15	101.81
Etna (ET)		18.75	433.19	73.76
Charleston (CH)		.	.	
All Roadside Stands (RSS)		20.78	504.31	85.78
Significances				
SM vs RSS	1	NS	NS	NS
Among DX, ET, CH	1	NS	NS	NS

Table 6. Vitamin A Activity and Alpha- and Beta-Carotene Content of Broccoli

Location	DF	Alpha-Carotene[1]	Beta-Carotene[1]	RE[2]
Supermarket (SM)		120.48	471.93	88.69
Dixmont (DX)		20.69	545.08	92.57
Etna (ET)		41.78	552.72	95.60
Charleston (CH)		31.40	510.47	87.69
All Roadside Stands (RSS)		24.94	538.92	91.89
Significances				
SM vs RSS	1	NS	NS	NS
Among DX, ET, CH	2	NS	NS	NS

See Table 2 for footnotes.

Table 7. Vitamin A Activity and Alpha- and Beta-Carotene Content of Green Onions

Location	DF	Alpha-Carotene [1]	Beta-Carotene [1]	RE [2]
Supermarket (SM)		4.04	429.19	71.86
Dixmont (DX)		.		
Etna (ET)				
Charleston (CH)		7.48	347.48	58.53
All Roadside Stands (RSS)		7.48	347.48	58.53
Significances				
SM vs RSS	1	NS	NS	NS
Among DX, ET, CH	0	.	.	.

Table 8. Vitamin A Activity and Alpha- and Beta-Carotene Content of Brussel Sprouts

Location	DF	Alpha-Carotene [1]	Beta-Carotene [1]	RE [2]
Supermarket (SM)		10.43	339.71	57.48
Dixmont (DX)				
Etna (ET)		12.17	279.48	47.59
Charleston (CH)				
All Roadside Stands (RSS)		12.17	279.48	47.59
Significances				
SM vs RSS	1	NS	NS	NS
Among DX, ET, CH	0	.	.	.

See Table 2 for footnotes.

Table 9. Vitamin A Activity of Alpha- and Beta-Carotene Contnet of Red Tomatoes

Location	DF	Alpha-Carotene[1]	Beta-Carotene[1]	RE[2]
Supermarket (SM)		159.06	240.97	53.41
Dixmont (DX)		277.11	472.47	101.83
Etna (ET)		276.56	959.73	183.00
Charleston (CH)		60.00	332.30	60.42
All Roadside Stands (RSS)		258.88	623.21	125.44
Significances				
SM vs RSS	1	NS	NS	NS
Among DX, ET, CH	2	NS	NS	NS

Table 10. Vitamin A Activity and Alpha- and Beta-Carotene Content of Peas.

Location	DF	Alpha-Carotent[1]	Beta-Carotent[1]	RE[2]
Supermarket (SM)		12.44	285.02	48.54
Dixmont (DX)		30.41	359.51	62.45
Etna (ET)		10.27	317.10	53.70
Charleston (CH)		35.91	358.90	62.80
All Roadside Stands (RSS)		28.16	347.58	60.27
Significances				
SM vs RSS	1	NS	NS	NS
Among DX, ET, CH	2	NS	NS	NS

See Table 2 for footnotes.

Table 11. Vitamin A Activity and Alpha- and Beta-Carotene Content of Green Beans

Location	DF	Alpha-Carotene [1]	Beta-Carotene [1]	RE [2]
Supermarket (SM)		45.97	232.68	42.61
Dixmont (DX)		53.26	291.58	53.03
Etna (ET)		46.00	266.70	48.28
Charleston (CH)		31.60	234.09	41.64
All Roadside Stands (RSS)		42.42	260.82	47.05
Significances				
SM vs RSS	1	NS	NS	NS
Among DX, ET, CH	2	NS	NS	NS

Table 12. Vitamin A Activity and Alpha- and Beta-Carotene Content of Green Peppers

Location	DF	Alpha-Carotene [1]	Beta-Carotene [1]	RE [2]
Supermarket (SM)		12.32	131.85	23.00
Dixmont (DX)		38.52	392.94	68.70
Etna (ET)		13.30	307.65	52.38
Charleston (CH)				
All Roadside Stands (RSS)		27.06	354.17	61.28
Significances				
SM vs RSS	1	NS	*	*
Among DX, ET, CH	1	NS	NS	NS

See Table 2 for footnotes.

Table 13. Vitamin A Activity and Alpha- and Beta-Carotene Content of Yellow Tomatoes

Location	DF	Alpha-Carotene[1]	Beta-Carotene[1]	RE[2]
Supermarket (SM)		.	.	.
Dixmont (DX)		0.000	69.71	11.61
Etna (ET)		.		.
Charleston (CH)		.	.	.
All Roadside Stands (RSS)		0.000	69.71	11.61
Significances				
SM vs RSS	0			.
Among DX, ET, CH	0	.	.	.

Table 14. Vitamin A Activity and Alpha- and Beta-Carotene Content of Corn.

Location	DF	Alpha-Carotene[1]	Beta-Carotene[1]	RE[2]
Supermarket (SM)		3.61	4.15	0.99
Dixmont (DX)		.	.	.
Etna (ET)		0.92	18.04	3.09
Charleston (CH)		0.00	12.66	2.11
All Roadside Stands (RSS)		0.64	16.43	2.79
Significances				
SM vs RSS	1	NS	NS	NS
Among DX, ET, CH	1	NS	NS	NS

See Table 2 for footnotes.

Table 15. SUMMARY OF ALPHA- AND BETA-CAROTENE CONTENT OF SUPERMARKET FRUITS AND VEGETABLES.

Samples	N	Alpha-Carotene[1] ug/100 g	Beta-Carotene[1] ug/100 g	RE/[2] 100 g
Carrots	26	3052.8	3605.9	855.4
Swiss Chard	21	34.6	2057.8	345.9
Beet Greens	21	11.1	1954.0	326.7
Cantaloupe	9	69.9	2055.0	348.3
Red Tomato	20	159.1	241.0	53.4
Broccoli	30	120.5	472.0	88.7
Buttercup Squash	15	27.7	996.9	168.4
Green Pepper	18	12.3	131.9	23.0
Peas	3	12.4	285.0	48.5
Green Onion	9	4.0	429.2	71.9
Brussels Sprouts	9	10.4	399.7	57.5
Green Beans	15	46.0	232.7	42.6
Yellow Tomato	0	-	-	-
Corn	3	4.0	4.1	1.0

N = Number of Subsamples

1 = Average Values

[2]RE= Retinol Equivalents/100 g Sample Based on Alpha- and Beta-Carotene Content

= No Samples

Table 16. SUMMARY OF ALPHA- AND BETA-CAROTENE CONTENT OF ROADSIDE STAND FRUITS AND VEGETABLES.

Samples	N	Alpha-Carotene[1] ug/100 g	Beta-Carotene[1] ug/100 g	RE/[2] 100 g
Carrots	43	2957.0	4002.9	913.6
Swiss Chard	31	31.0	3177.6	532.2
Beet Greens	29	15.9	2428.4	406.1
Cantaloupe	12	54.8	1557.8	264.2
Red Tomato	36	258.9	623.2	125.4
Broccoli	30	25.0	538.9	91.9
Buttercup Squash	21	20.8	504.3	85.8
Green Pepper	33	27.1	354.3	61.3
Peas	22	28.2	347.6	60.3
Green Onion	8	7.5	347.5	58.5
Brussels Sprouts	9	12.2	279.5	47.5
Green Beans	34	42.4	260.8	47.0
Yellow Tomato	12	0.0	69.7	11.6
Corn	10	0.0	16.4	2.8

N = Number of Subsamples

1 = Average Values

[2]RE= Retinol equivalent/100 g Sample Based on Alpha- and Beta-Carotene Content

0.0 = None detected at a Detection level 4 ug/100 g Sample