B Vitamin Content of California-Grown Avocados

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Little information is available on either the proximate analysis or vitamin content of the different varieties of avocado. Changes in the concentration of these nutrients with crop year, season, and period of refrigeration or ripening after refrigeration are also largely unknown. This study included such comparisons for seven B vitamins as well as the usual proximate analyses in samples from four crop years of Fuerte, two of Anaheim, and one of Hass avocados.

THE AVOCADOS grown in California are of two races, of Mexican and Guatemalan origin. The Fuerte is a hybrid of the two races; the Anaheim and Hass are of the Guatemalan race. About 80% of the California crop is of the Fuerte variety, which ripens from October to June. The Anaheim is the most prominent of the low-oil avocado varieties ripening from June to September and the Hass is a sturdy variety increasingly popular with growers, ripening from May to October.

Three varieties of California-grown avocados, Fuerte, Anaheim, and Hass, of four crop years, were examined for content of most of the B vitamins, with attention also to the fat and water contents and the effect of various periods of refrigeration and ripening at room temperatures.

Few reports on the vitamin composition of this fruit have been made. A few early analyses and a study by Lassen, Bacon, and Hinderer (*10*) constitute most of the available data. Most of these reports give no information on variety or source of the sample (*16*).

Methods

The samples analyzed were all received from the Calavo Growers of California, those for each crop year being obtained from the same area. Boxes of the fruit were shipped at intervals during the 2- to 3-month tree ripening periods. All fruits were stored at once in the refrigerator at 4° to 5° C. and samples removed at intervals of 1 to 61 days. These samples were then kept at room temperature from 0 to 5 days to determine the effect of any further ripening. The fruits were then peeled and ground, packed in Pliofilm, and stored at freezer temperature (−10° C.) until the analyses were completed.

Proximate analyses by the official methods were carried out on representative samples of each variety, and water and fat determinations were made on most of the individual fruits used for the vitamin assays. The vitamin analyses were done by microbiological and fluorometric methods previously described (*5*). A combination of the thiochrome methods of Hennessy and Cerecedo (*7*) and Conner and Straub (*3*) was used for thiamine and the usual microbiological procedures were used for riboflavin and niacin. The fluorometric method of Peterson, Brady, and Shaw (*13*) was also used for riboflavin and in some cases the microbiological assay with *L. mesenteroides* 10,100 (kindly provided by V. H. Cheldelin, Oregon State College, Corvallis, Ore.) suggested by Kornberg, Langdon, and Cheldelin (*9*). In a series of 11 comparative assays the riboflavin values for Anaheim 1953 avocado samples yielded by the *L. casei* and *L. mesenteroides* organisms were 2.00 ± 0.11 (mean ± standard error) and 1.89 ± 0.08 γ per gram, respectively. In 10 similar assays of Hass 1953 samples the values were 2.23 ± 0.06 and 2.05 ± 0.07. Ether extraction of these samples was found to have no significant effect upon the riboflavin yield.

The extraction for pantothenic acid was done with mylase-P (*8*) and the microbiological procedure was that of Skeggs and Wright (*14*).

Folic acid was determined by the method of Bird and coworkers (*2*) using hog kidney enzyme for digestion and *S. faecalis* No. 8043 as the organism. The samples were found to yield slightly higher values if they were not heated before the digestion. The chicken pancreas enzyme (*11*) was also tried for the digestion, but this produced lower and more variable results than the hog kidney preparation and so was discarded. A new dehydrated chicken pancreas enzyme (distributed by Difco Laboratories, Detroit, Mich.) became available later and was used successfully on the 1953 crop samples.

Vitamin B_6 (pyridoxine) was determined by the method of Atkin and coworkers (*1*) and biotin by the procedure of Wright and Skeggs (*17*) using *L. arabinosus*. The samples were autoclaved for 2 hours at 15-pound pressure in 2*N* sulfuric acid for extraction.

Six bioassays using rat growth as criterion of vitamin content were made on Fuerte samples of the 1950, 1951, 1952, and 1954 crops and on the Hass samples of 1953. The method has been described (*5*).

Results

The proximate analyses shown in the summary table (Table I) indicate the variability of the water and fat content of the fruits. Increased fat was usually accompanied by decreased moisture. The Anaheim variety had little more than half to two thirds of the fat content shown by the Fuerte and Hass samples.

Effect of Season. Seven shipments of the 1950 Fuertes were examined for effects of tree ripening. These samples were shipped between January 23 and April 26, thus covering most of the harvesting season in Southern California. In Table II the moisture, fat, thiamine, and riboflavin contents of these samples are given. No pattern can be seen, there being no discernible trend in any of these constituents traceable to season. The mean values and standard errors calculated from these 56 analyses present a fair picture of the composition of the Fuerte avocado.

Effect of Refrigeration and Room Temperature Ripening. The fruits were kept under refrigeration up to 61 days after they were received. In Table III these periods are divided into five groups ranging from 8 to 13 days up to 43 and 61 days, and moisture, fat, thiamine, and riboflavin are reported. In these 45 analyses again there is little discernible pattern, although a slight increase in fat and decrease in moisture appear with lengthened storage period.

When the period of room temperature ripening was varied from 0 to 5 days, again there was no significant trend. The storage periods preceding these varied ripening periods were sometimes different also, but the differences between individual fruits of the same storage period and the same room temperature ripening period were as great as those of different storage and ripening history.

B Vitamin Analyses. Summaries of the B vitamin analyses for all samples are given in Table IV. Complete results for all varieties and crop years are presented for riboflavin, niacin, folic acid, and pantothenic acid and nearly as complete results for thiamine. There were three sets each of assays made for vitamin B_6 (pyridoxine) and biotin.

The Fuerte avocado had a higher mean content of thiamine, 0.12 mg. %, than either of the two other varieties, 0.08 and 0.08 mg. %, but riboflavin was nearly the same in all varieties and all crop years, 0.19 to 0.25 mg. %. The values found by microbiological means were usually about 85% of those yielded by the fluorometric method. Niacin was found in about the same amount in the Fuertes and Anaheims, but the Hass had a significantly larger content. Pantothenic acid was slightly lower in the Fuertes than in the other two varieties, 0.9 mg. % compared with 1.12. Vitamin B_6 was lower in the 1953 Anaheims, 0.39 mg. %, than in the Fuertes and Hass, 0.61 and 0.62. Folic acid likewise was lower in the Anaheims, 0.018 mg. %, than in the Fuertes, 0.031, and Hass, 0.040. The same was true of biotin, 0.034 γ per gram compared with 0.055 and 0.056. The sum of moisture and fat in most of these samples was fairly constant, about 91%, so that the differences in vitamin content may be considered valid even though total solids varied.

Bioassays. It is usually necessary to make one or more rat-growth or other type of bioassay in order to validate the effectiveness of the extraction procedures which must precede the chemical or microbiological tests for vitamins in foods, particularly those of low potency. The bioassays generally yield a higher apparent concentration of the vitamin than do the other types of analyses. Comparisons of this type have been made in this laboratory in prunes (*12*), figs (*5*), turkey tissues (*4*), and walnuts (*6*).

Bioassays for thiamine, riboflavin, pantothenic acid, and vitamin B_6 were carried out on Fuerte samples of four different crop years. A vitamin B_6 bioassay was also made on the Hass samples of 1953. In the thiamine and one of the pantothenic acid assays the rat-growth values were greater, 36 and 40%, respectively, than those obtained by other means. The other assay for pantothenic acid and that for vitamin B_6 on the Hass sample yielded excellent agreement with the results of the microbiological analysis, 101 and 109% of the latter values. This was true also of the riboflavin assay. In the other vitamin B_6 assay, on the Fuerte fruit, the bioassay showed about one third smaller value than that obtained by microbiological procedure. This may reflect the improved extraction procedures used in the microbiological analyses or else poor absorption of the rather large avocado test doses, 1 to 3 grams, fed daily to the young rats.

A summary of the composition of these three varieties is given in Table IV with averages and ranges for the nutrients determined.

Avocados as a source of thiamine compare favorably with nearly all fruits and vegetables, with fish, milk, and eggs, and with all meats except pork, and are exceeded in thiamine content chiefly by the whole grains. As a source of riboflavin avocados are exceeded in concentration chiefly by evaporated milk, cheese, liver, and other organ meats. They are equal or superior to most other fruits, vegetables, meat, fish, cereals, and legumes. They contain more niacin than most fruits and vegetables, milk, cheese, and eggs, but less than most meats, fish, whole grains, and some legumes. Avocados appear to be in the middle range of all foods as a source of folic acid (*15*), but data are not numerous or consistent enough as yet to make valid comparisons. This is true also of pantothenic acid, vitamin B_6, and biotin. It is plain, however, that this fruit is in the superior group of foods as a source of both pantothenic acid and vitamin B_6.

Table I. Average Composition of Avocados

	Fuerte[a]		Hass[b]		Anaheim[c]	
	Average	Range	Average	Range	Average	Range
Water, %	73.8	67–82	68.4	65–73	79.3	72–83
Fat, %	17.0	12–23	20.0	17–23	11.2	7–15
Ash, %	1.4	1.1–1.6	1.2	1.1–1.3	1.0	0.9–1.03
Protein, %	2.5	2.3–2.6	2.6	2.3–2.9	1.8	1.3–2.9
Carbohydrate, %	5.3	...	7.8	...	6.7	...
Thiamine, mg. %	0.12	0.08–0.14	0.09	0.08–0.12	0.08	0.06–0.10
Riboflavin, mg. %	0.22	0.14–0.29	0.23	0.20–0.25	0.21	0.15–0.26
Niacin, mg. %	1.45	1.0–1.6	2.16	1.9–2.4	1.56	1.2–2.0
Pantothenic acid, mg. %	0.90	0.8–1.4	1.14	0.9–1.4	1.11	0.6–1.5
Vitamin B_6, mg. %	0.61	0.5–0.7	0.62	0.4–0.8	0.39	0.24–0.65
Folic acid, mg. %	0.03	0.01–0.05	0.04	0.02–0.06	0.018	0.01–0.03
Biotin, γ/g.	0.055	...	0.056	0.04–0.07	0.034	0.02–0.04

[a] Samples of 1950, 1951, 1952, and 1954 crops included, 15 to 40 analyses for each figure.
[b] Samples of 1953 crop, 5 to 14 analyses for each figure.
[c] Samples of 1951 and 1953 crops, 6 to 12 analyses for each figure.

Table II. Effect of Period of Tree Ripening on Moisture, Fat, Thiamine, and Riboflavin Content of Fuerte Avocados (1950)

Date of Harvest	Period in Refrigerator, Days	No. of Analyses	Moisture, %	Fat, %	Thiamine, Mg. %	Riboflavin, Mg. %	
						Micro.	Fluor.
Jan. 23	1–12	4	...	...	0.13	0.19	0.24
	17–32	7	77.5	15.8	0.10	0.18	0.20
Feb. 13	8–19	6	75.7	15.0	0.12	0.19	0.24
	20–26	6	73.5	16.6	0.12	0.20	0.23
March 6	12–17	9	75.4	14.9	0.10	0.21	0.22
March 29	21–61	6	72.1	16.4	0.11	0.17	0.21
April 1	0	4	71.9	19.7	0.11	...	...
April 10	34–58	6	74.2	16.2	0.10	0.18	0.22
April 26	20–43	8	71.0	20.8	0.12	0.18	0.24
Totals or means	...	..	74.1	16.8	0.11	0.19	0.23
Standard error	...	..	0.7	0.7	0.004	0.004	0.005

Table III. Effect of Period in Refrigeration and Ripening at Room Temperature on Composition of Fuerte Avocados (1950)

Variety and Year	No. of Analyses	Period of Refrigeration, Days	Ripening at Room Temp., Days	Moisture, %	Fat, %	Thiamine, Mg. %	Riboflavin, Mg. % Micro.	Riboflavin, Mg. % Fluor.
Fuerte 1950	8	8–13	0–5	76.6	14.8	0.11	0.19	0.23
	9	17–21	2–4	73.1	17.7	0.11	0.21	0.25
	9	23–29	2–5	75.0	16.6	0.13	0.18	0.22
	9	31–42	1–5	74.2	16.1	0.11	0.17	0.22
	10	43–61	0.4	71.7	18.5	0.10	0.18	0.24
Totals or means	45	8–61	0–5	73.3	16.8	0.11	0.19	0.23
	4	13–43	0	73.5	17.3	0.11	0.19	0.20
	4	12–42	1	72.3	17.2	0.10	0.20	0.21
	13	20–55	2	72.0	17.3	0.12	0.18	0.23
	14	5–48	3	75.3	16.0	0.11	0.19	0.23
	7	0–58	4	72.1	20.0	0.11	0.20	0.23
	9	1–32	5	76.9	14.9	0.12	0.18	0.21
Totals or means	51	1–58	0–5	73.9	17.0	0.11	0.19	0.22

Table IV. B Vitamin Distribution in Three Varieties of California-Grown Avocados

Variety and Year	No. of Analyses	Moisture, %	Fat, %	Thiamine, Mg. %	Microbiological Methods: Riboflavin, mg. %	Niacin, mg. %	Pantothenic acid, mg. %	Folic acid, mg. %	Vit. B_6, mg. %	Biotin, γ/g.
Fuerte										
1950	5–6	74.1	16.8	0.11	0.19	...	...	...	...	...
1951	4–8	70.6	19.8	0.13	0.25	1.52	0.97	0.029	...	...
1952	4–8	69.8	...	0.13	0.23	1.25	0.85	0.34	0.61	...
1954	2–5	73.7	17.3	...	0.19	1.57	0.89	0.026	...	0.055
Anaheim										
1951	3–8	80.0	10.1	0.09	0.20	1.60	1.01	0.018	...	...
1953	7–15	78.6	12.3	0.08	0.21	1.52	1.21	0.019	0.39	0.034
Hass										
1953	7–12	68.4	20.0	0.09	0.23	2.16	1.14	0.040	0.62	0.056
Avocados[a]	...	65.4	26.9	0.06	0.13	1.1	...	0.017 to 0.056[b]	...	...

[a] (*16*).
[b] (*15*).

The fact that the fruit is eaten uncooked adds to its value as a source of the water-soluble B vitamins.

Summary

No consistent effect upon the moisture, fat, or vitamin content of avocados was found to result from the season, crop year, period in refrigeration, or period of ripening at room temperature.

In the three varieties studied, the greatest variable was the fat content, which was 17 to 20% in the Fuerte and Hass varieties, but only 10 to 12% in the Anaheim.

The average thiamine content of the Fuerte fruit was 0.12 mg. %, but the Hass and Anaheim fruit contained 0.08 to 0.09 mg. %. Riboflavin concentration was 0.19 to 0.23 mg. % in all the avocados. Niacin likewise was much the same in the Fuerte and Anaheims, average 1.5 mg. %, but the Hass had 2.16 mg. %. Pantothenic acid was slightly higher in the Anaheims and Hass than in the Fuertes, 1.14 mg. % compared with 0.9. Vitamin B_6 and biotin had the same values in Fuertes and Hass, but only about 60% of this in the Anaheims. Folic acid was also lower in the Anaheims than in the Fuertes and Hass.

Thus lower values for thiamine, folic acid, vitamin B_6, and biotin as well as for fat characterize the Anaheims. Lower thiamine but high niacin, folic acid, and pantothenic acid are found in the Hass as compared with the Fuerte. All these differences are small, however, in view of the variability from sample to sample.

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