THE NUTRITIVE VALUE OF NEW ZEALAND SPINACH

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Received for Publication—July 3, 1929

NEW ZEALAND spinach (*Tetragonia expansa*) is a comparatively new kind of market greens. Its particular advantage is in its being heat tolerant. In the hot summer months when spinach and some other green vegetables cannot be grown, New Zealand spinach, which is not a variety of spinach (*Spinacia oleracea*), is easily grown as a truck crop and furnishes succulent greens for months. Furthermore it is being grown as a winter crop in some eastern greenhouses. The tender, rather fleshy leaves have a distinct flavor more pleasing to some than that of common, mild spinach.

The nutritive value of any vegetable used as a salad or for greens is dependent largely on its mineral and its vitamin contents. The few references to New Zealand spinach in the literature (3, 7) show it to be high in minerals, especially iron. No references were found to its vitamin content. Its appearance, flavor and composition, as found in our experimental work, are recommendation enough. It is compared with spinach only because this has previously been shown to be exceptionally rich in minerals and potent in vitamins. The use of spinach has been advocated to such an extent that recognition of other vegetables with different flavors is needed before unfavorable reaction towards eating spinach becomes too great.

Mineral Content

Raw and cooked samples were analyzed for moisture, total ash, calcium, phosphorus and iron. Leaves alone were used for analysis because much of the stem, particularly in older plants, is tough and fibrous. Samples of New Zealand spinach, as gathered in the college greenhouse or garden, showed no dirt visible to the eye and washing yielded a negligible amount of foreign matter. Therefore, the raw vegetable was analyzed without washing. It was weighed as soon as possible after picking and put into a vacuum oven,

* Spinach and New Zealand spinach were grown and furnished through the courtesy of Dr. E. S. Haber. Most of the total ash, calcium and phosphorus determinations were made by Carrie Hodges, some of the vitamin A determinations by Lena Gilbert and some of the vitamin B determinations by Iva Mullen, in partial fulfillment of the requirements of each student for the degree of Master of Science.

set at 70° C, to get the moisture content. The dried material was ashed in an electric muffle furnace at dull red heat. The ash for calcium and phosphorus determinations was dissolved in hydrochloric acid as described by Clark (2). Calcium was precipitated as the oxalate in the presence of acid (pH 4.8) and determined by titration against permanganate (9). Phosphorus was determined by a modification of the Pemberton-Kilgore method (6), precipitating the phosphomolybdate, dissolving this in standard sodium hydroxide, and back titrating. Iron was determined colorimetrically by the Walker method (4).

As shown in Table I, raw New Zealand spinach is exceptionally high in mineral salts, is a very good source of iron and of calcium but not of phos-

TABLE I

PERCENTAGE COMPOSITION OF NEW ZEALAND SPINACH LEAVES[4]

	Water	Water	Ash	Ash	Ca	P	Fe	Protein (Nx6.25)	Oxalic acid, anhydrous
Av.	94.0[1]	88.4[2]	1.92[1]	2.43[2]	.045	.027	.0023	1.4	.49
P.E.[3]	0.3	1.1	0.01	0.05	.002	.002	—	0.2	.03
Max.	95.0	89.8	1.94	2.58	.050	.030	.0024	1.7	.53
Min.	93.3	85.6	1.90	2.38	.038	.022	.0022	1.1	.40
No. anal.	18	11	5	6	10	6	5	8	8

[1] Samples grown in greenhouse.

[2] Samples grown in garden.

[3] Probable error of the mean.

[4] Lichtin (7) gives the following percentages: 1.86 ash, and 0.00456 iron, in New Zealand spinach grown at Cornell; 2.59 ash, and 0.00328 iron, in samples from the open market.

phorus. These facts are brought out by comparison with other common leafy vegetables shown in Table II.

Changes in mineral content caused by cooking are brought out in Table III. The greens were prepared for cooking in the usual way and two methods of cooking were employed. First, the weighed leaves were washed in tap water and cooked in the clinging wash water only in the top of an enamel double boiler; second, the weighed sample, after washing, was put into a measured volume of boiling tap water and cooked for a definite period. In each case the cooked product was drained and both the spinach and the cooking liquor dried and analyzed. Mineral contents were calculated on the basis of the fresh raw weight.

New Zealand spinach cooked without added water retains its distinctive

flavor with a somewhat astringent after taste. Fifty minutes in a double boiler gave a mushy product, thirty-five minutes a tender one though the brilliancy of the green color was lost. One-sixth of the mineral salts, including one-eighth to more than one-fourth of the iron, was drained off

TABLE II

PERCENTAGE COMPOSITION OF SOME LEAFY VEGETABLES

	Water[1]	Ash	Ca[2]	P[2]	Fe	Oxalic acid, anhydrous
Cabbage	91.5	1.0[1]	.045	.029	.0011[3]	.0056[5]
Lettuce	94.7	0.9[1]	.043	.042	.0007[3]	trace[6]
Spinach	92.3	2.1[1]	.067	.068	.0036[3]	.299[6]
		1.41[2]			.0061[3]	
					.0031[4]	

[1] Atwater and Bryant (1).
[2] Lichtin (7).
[3] Sherman (11, appendix B).
[4] Spinach grown under same conditions as New Zealand spinach of our analyses.
[5] Floyd, L. P., Unpublished Master's Thesis, Univ. of Chicago, 1923.
[6] Arbenz, E., *Mitt. Lebensm. Hyg.* 1917, VIII, 98.

TABLE III

COOKED NEW ZEALAND SPINACH LEAVES

	Wt. of raw sample	Vol. of water	Time cooked	Green color	Flavor	Percent Mineral Losses calculated on basis of 100 g. raw			
						Ash	Ca	P	Fe[2]
	gr.	cc.	min.						
A[1]	150	*	50	olive	very strong	28.4	5.1	—	
B	150	*	35	"	Strong	15.6	4.5	—	
C	420	*	35	"	"	14.8	4.7	5.8	13
D	420	*	35	"	"	15.6	4.5	5.5	28
E	420	*	35	"	"	15.7	5.1	5.8	28
A	150	500	20	bright	Mild	44.8	6.1	—	
B	150	150	14	"	"	41.9	6.1	—	
C	140	750	10	"	"	39.8	6.1	63.4	37
D	420	750	10	"	"	40.6	5.9	62.9	40
E	420	750	10	"	"	40.5	6.8	62.4	44
F	420	750	10	"	"				47

* Water clinging to leaves from washing.
[1] Samples A, B and D were drained 10 min., C, 60 min.; and E, 5 min.
[2] Iron was not determined in the same samples as those used for analyses of other minerals. All samples for iron determinations were drained for 10 min.

in the strong cooking liquor but little of the calcium or phosphorus was lost.

Ten minutes cooking in excess boiling tap water gave an attractive tender product with a very mild flavor. Draining away the liquid took with it little calcium but about 40 per cent of the total mineral salts and of the iron, and more than 60 per cent of what phosphorus the raw vegetable contained.

Using our figures for composition of New Zealand spinach, and average composition figures of Atwater and Bryant (1) and of Sherman (11) for the other common leafy vegetables, New Zealand spinach, even when cooked in a large volume of water and drained longer than is customary before serving, is found to be as rich in mineral salts as raw spinach and to be richer in iron and as high in calcium as lettuce or cabbage served raw.

Vitamin Potency

Only raw leaves were tested for vitamin content. Albino rats from our stock colony were used for most determinations. The diet of the mothers of other rats used had been similar, that is, largely grain with milk added. Our stock diet is Steenbock's (14) modified to contain wheat germ and yeast, and supplemented at intervals by lettuce. The laboratory technic was that of Ferry (5). Rats were weaned at 28 or 29 days and placed directly on the experimental diet in individual cages. The basal diet consisted of purified casein 18 per cent, dextrinized cornstarch (8) 76 per cent, salt mixture (10) 4 per cent, and agar 2 per cent.

Vitamin A. For vitamin A tests the casein was made A-free (12), the diet irradiated and a salt spoonful of yeast, weighing approximately 0.4 gram, was fed separately six times a week. The method used was essentially that of Sherman and Munsell (12). Cessation of growth was the chief criterion for deciding when the store of vitamin was depleted. The basal diet was then supplemented during the 8-week period with carefully weighed quantities of New Zealand spinach or spinach leaves (Bloomsdale) having, so far as possible, an upper surface area of 4 to 5 square inches. To minimize errors in weighing, the very small quantities of leafy tissue were fed three times a week. Twenty-six negative controls, with an average weight of 50 grams at 28 days, survived 53.5 days on the average or 21 to 22 days after the average depletion period.

Close to 90 mg. of New Zealand spinach per week were required to allow a gain in weight of approximately 3 grams a week for 8 weeks, after depleting our rats which at 28 days weighed on the average about 50 grams. A slightly smaller quantity of ordinary spinach grown under the same

conditions induced a somewhat larger gain with a correspondingly greater consumption of the basal diet. However, it is clearly shown that New Zealand spinach, like spinach, is several times as rich in vitamin A as are most green foods that have been tested.

Vitamin B. The method used was essentially that of Sherman and Spohn (13). Vitamins B and G were considered as an entity. The same

TABLE IV
VITAMIN A TESTS

Amt. per wk.	No. of rats	Wt. at 28 days.	Pre-period	Initial wt.	Gain in period	Food eaten weekly	Rats surviving period
			New Zealand Spinach				
gr.		gr.	days	gr.	gr.	gr.	no.
0.09	16	52	33	127	27.4	66	11
0.08	15	50	30	109	16.8	52	12
0.07	15	49	35	119	−11.6	54	8
			Spinach				
0.07	7	46	30	125	32.5	69	7

TABLE V
VITAMIN B CONTENT OF LEAVES

Amt. per day	No. of rats	Initial wt.	Weekly change in wt.	Food eaten weekly	Time of survival	Rats surviving period	Gain in wt. of survivors
			New Zealand Spinach				
gr.		gr.	gr.	gr.	days	no.	gr.
1.0	7	50	−1.5	24.6	41	1	8
1.2	7	47	−0.4	25.6	49	4	2
1.4	8	50	−0.3	27.3	49	4	10
1.6	8	37	+3.3	21.4	56 (K)	8	26
			Spinach				
1.0	8	49	+2.5	32.6	50	6	29
1.2	10	49	+3.4	34.9	56 (K)	10	27
1.4	7	37	+6.5	35.8	56 (K)	7	52

K denotes killed.

basal diet was used as for vitamin A determinations except that it was not irradiated and the casein was made B-free (13). Cod-liver oil, five drops per day, was fed separately. The New Zealand spinach and the spinach was the same as for vitamin A tests but was fed six times per week with a double portion on Saturdays. Fifteen rats, with an average weight of 46 grams at 28 days, used as negative controls, survived for 40 days on the average, with an average loss of 2.6 grams in weight per week.

It requires a little more than 1.4 grams of New Zealand spinach daily to maintain a 50 gram rat at constant weight for 8 weeks On 1.6 grams daily, 37 gram rats make a distinct gain, but just one-half as great as that made by rats of the same weight getting 1.4 grams of spinach (*Spinacia oleracea*). The latter rats showed an appetite for the basal diet one-half again as great. New Zealand spinach, though it contains somewhat less vitamin B complex than does spinach, belongs in the same class with it.

Summary

New Zealand spinach is especially valuable in the diet because of its high salt content. It compares favorably with most green vegetables in iron and calcium.

Cooked without addition of water, it retains most of its minerals.

If greens of milder flavor and brighter color are preferred, it may be boiled in water with little loss of calcium but with much loss of other minerals. However, it still retains enough to compare favorably with raw cabbage or lettuce.

New Zealand spinach is exceedingly rich in vitamin A and is a good source of vitamin B complex.

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