

THE NUTRITIVE VALUE OF GREEN IMMATURE SOYBEANS¹

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INTRODUCTION

Much information is available regarding the nutritive value of dry soybeans and products made from them, whereas the green immature soybeans have been little studied. When it was learned that orientals, especially Japanese, in Hawaii as well as in the Orient, use the green soybeans, experiments were planned to obtain information regarding the composition and vitamin content of the local product.

Green immature soybeans look much like young, tender lima beans, but they have a richer, more distinctive, and more delicious flavor. It is usually desirable to cook them in the pods, boiling them in salted water from 15 to 25 minutes. The beans then slip easily from the pods and can be used in salads or in soups and as a vegetable. The orientals often eat them directly from the pods, especially between meals. Children sometimes carry about a small paper bag of the cooked beans, break open the pods, and then lick the beans out with their tongues—a practice to be recommended from the sanitary as well as from the nutritive standpoint.

Chung and Ripperton (2)² have reported determinations of calcium, phosphorus, iron, and other nutritive constituents in raw green soybeans raised in Hawaii. Saiki and coworkers (8) have reported similar analyses from Japan. Piper and Morse (7) have reported one analysis, and Muramatsu (6) has studied the comparative starch content of green and dry soybeans. No reports of vitamin studies of raw or cooked green soybeans have been found in the literature.³

METHODS AND EXPERIMENTAL DATA

COMPOSITION OF GREEN SOYBEANS

The nutritive constituents and mineral elements of the raw and of the cooked green, immature soybeans were determined by the methods of the Association of Official Agricultural Chemists (1) or by slight modifications of these procedures. Iron was determined by the method recommended by Elvehjem and Hart (3).

Through the courtesy of C. P. Wilsie, agronomist of the Hawaii Agricultural Experiment Station, one of the varieties of beans used for the analyses and feeding tests was grown on the university farm. The seeds of these soybeans (Seaweed, F.P.I. no. 80483) were obtained from W. J. Morse, of the United States Department of Agriculture, who had obtained them from Japan and who stated that they were used only in the green state. When mature, the seeds are large and flat, with a testa pattern of a black saddle on a yellow base. In

¹ Received for publication Mar. 21, 1934, issued August 1934.

² Reference is made by number (italic) to Literature Cited, p. 167.

³ Brief reference is made to such studies by Miller (5, p. 2).

the fresh green state in which they were analyzed they were light green with a purplish-red saddle that changed to bluish-gray on cooking.

Beans of unknown variety bought on the open market appeared bright green after cooking and were not so flat in shape as the Seaweed variety.

For the analyses, the fresh green soybeans were removed from the pods and dried in large evaporating dishes in an enamel-lined oven at a temperature below 80° C. The cooked green soybeans were prepared by boiling in salted water for 20 to 25 minutes, after which the beans easily slipped from the pods and were dried in the same manner as the fresh soybeans. For the iron analyses, the soybeans were ashed wet to avoid contamination.

Table 1 summarizes the analyses of one variety (F.P.I. no. 80483) in the uncooked and in the cooked states, and of a local unknown variety in the cooked state only.

TABLE 1.—Composition of fresh green soybeans

Treatment of green soybeans	Moisture	Protein	Ether extract	Crude fiber	Ash	Carbohydrates (by difference)	Calcium	Phosphorus	Iron
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Cooked ¹	64.2	15.0	2.7	1.6	2.9	13.6	0.100	0.257	0.00213
Do. ²	63.5	13.8	4.2	1.5	3.1	13.9	.098	.286	.00344
Raw ³	69.1	12.5	5.1	1.5	1.8	10.0	.063	.239	.00283

¹ Variety unknown; purchased on open market; 2 samples.

² Variety (F.P.I. no. 80483); grown on university farm; 2 samples.

³ Variety (F.P.I. no. 80483); grown on university farm; 1 sample.

The analyses show that the protein content of green soybeans is from 12.5 to 15 percent, an unusually large percentage for a fresh green vegetable.

Muramatsu (6) reports that the dry soybeans contain little or no starch, but that the unripened, green soybeans contain from 2.6 to 4.76 parts per 100 parts of dry material. Investigations of others cited by Muramatsu show the nitrogen-free extract of dry soybeans to be made up of sugars, dextrin, pentosans, galactans, cellulose, waxes, and coloring matter. Consequently, in table 1 the figures given for carbohydrates by difference, constituting approximately 14 percent of the cooked soybeans, do not represent all utilizable carbohydrate.

The figures for ether extract show from 3 to 4 percent of fat in the cooked green soybeans as compared with 12 to 18 percent in four varieties of dried soybeans reported by Wu (11).

The crude fiber of the green, immature soybeans is 1.5 percent, as compared with 3.4 to 6.8 percent for four varieties of dry soybeans reported by Wu (11). This low crude fiber content should permit of a higher percentage utilization of the organic nutrients and of the minerals in the green soybeans than in dry legumes.

The energy value of cooked green soybeans is relatively high, as it takes only 70 g or one-half of a cupful to yield 100 calories.

The calcium content of 0.1 percent compares favorably with that of milk and is much higher than in most vegetables. Moreover,

the phosphorus content of 0.286 percent is much higher than that of other vegetables or milk. The iron content of green soybeans exceeds that of most other common vegetables reported by Sherman (9).

Analyses made by the authors confirm those previously reported for the fresh raw soybeans and indicate that cooked green soybeans are a vegetable of great nutritive value in the oriental diet. People of other countries might well add them to their diet.

VITAMIN METHODS AND DETERMINATIONS

The methods used for the quantitative determination of the vitamins were essentially those recommended by Sherman (9). The rats were standard animals raised by the Hawaii Station. All the usual precautions recommended for carrying out quantitative vitamin tests were followed.

Both of the varieties previously referred to were used for the feeding tests, but no difference could be detected in their vitamin content, either when fed during the same or different experiments. Twice a week a fresh supply of beans was cooked in the pods in salted water for 25 minutes. The beans were removed from the pods and stored in a tight-fitting glass jar in an electric refrigerator until used.

The supplements were weighed on a chainomatic balance and were fed daily, except the 0.25-g supplements for the vitamin A experiments which were fed as 0.5 g three times a week.

The term "daily feedings" is here used to mean feedings given every day except Sunday.

VITAMIN A

For the vitamin A experiments, young rats were weaned and placed on the experimental diet at the age of 3 weeks, when they weighed an average of 40 g.

Table 2 and figure 1 summarize the results of feeding cooked green soybeans as the sole source of vitamin A to 21 standard white rats. One rat fed daily 0.5 g of green soybeans and two fed daily 0.25 g succumbed several weeks after the supplements were started. Their records are not included in the results.

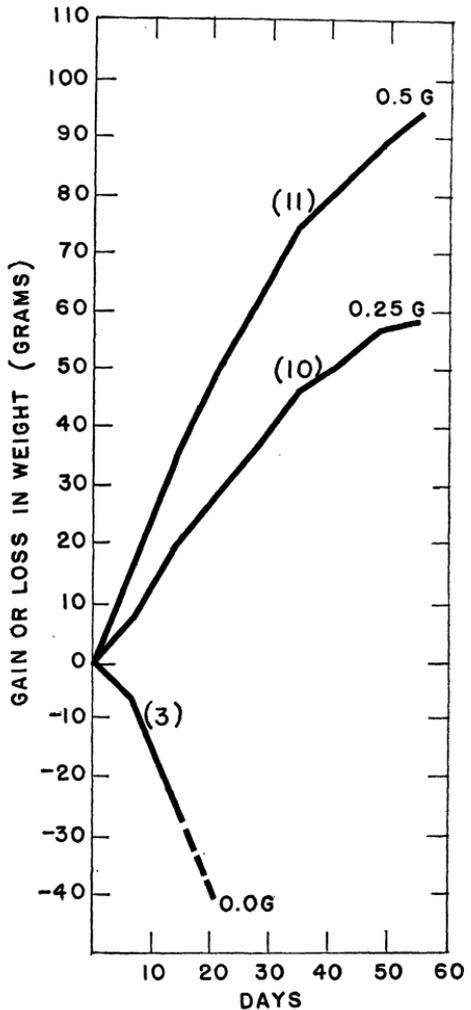


FIGURE 1.—Average gain in weight of groups of young rats fed various amounts of cooked immature soybeans as the sole source of vitamin A. The broken line indicates the occurrence of the first death in the control group. The numbers in parentheses show the number of rats used for each test.

TABLE 2.—Results of feeding various amounts of cooked green soybeans to rats as the sole source of vitamins A, B, and G

Vitamin studied and source	Rats	Weight of supplement fed daily	Average weights			Average gain (+) or loss (-) in 8 weeks
			Initial	When supplement started	Final	
Vitamin A:	<i>Number</i>	<i>Grams</i>	<i>Grams</i>	<i>Grams</i>	<i>Grams</i>	<i>Grams</i>
Negative control.....	3	0.00	37	¹ 110	81	-----
Green soybeans, cooked.....	10	.25	40	119	178	+59
Do.....	11	.50	41	121	216	+95
Vitamin B:						
Negative control.....	2	0.00	52	¹ 73	50	-----
Green soybeans, cooked.....	8	1.00	57	80	102	+22
Do.....	7	1.30	57	79	110	+31
Vitamin G:						
Negative control.....	3	0.00	46	¹ 55	54	-1
Green soybeans, cooked.....	2	1.00	47	52	65	+13
Do.....	12	1.50	48	58	101	+43
Do.....	7	2.00	46	54	102	+48
Do.....	2	4.00	46	54	152	+98

¹ Weight at the end of the depletion period.

The growth curves indicate that green cooked soybeans are a very good source of vitamin A. Ten rats gained an average of 59 g in 8 weeks when fed daily 0.25 g of cooked green soybeans, and 11 rats gained an average of 95 g in 8 weeks when fed daily supplements of 0.5 g.

Despite this excellent growth response many of the rats showed abnormal conditions at autopsy. Three rats fed the 0.5-g supplements had bladders with thickened and hemorrhagic walls containing calculi. Three showed kidneys with enlarged sinuses. Six rats fed the 0.25-g supplements had abnormal bladders with hemorrhagic and thickened walls. Three showed kidneys with enlarged sinuses. Three had slightly swollen eyelids.

All of the male rats on the 2 supplements showed poor sexual development; the testes were practically always small, and microscopic examination showed few if any mature sperms in the cauda epididymis. On the other hand, the females were better developed sexually and their ovaries appeared to be normal with ripening or large ripe follicles.

Twelve animals, 6 in each group, tended to drag their hind legs and had as a result a very unsteady gait.

No attempt was made to feed supplements smaller than 0.25 g, since it had been observed that rats gaining much less than 60 g in the 8-week period suffered such high mortality from kidney and bladder infections, and occasionally from lung infection, that it was useless to try to obtain gains of 25 to 30 g in 8 weeks.

VITAMIN B

Young rats weaned when 25 and 26 days old averaged 57 g in weight when placed on the vitamin-B-free diet.

The results of feeding 15 standard rats cooked green soybeans as the sole source of vitamin B are summarized in table 2 and figure 2.

The growth curves show that cooked green soybeans, like most legumes, are a good source of vitamin B. Eight rats fed daily supplements of 1 g of cooked green soybeans gained an average of 22 g in 8 weeks, and 7 rats fed 1.3-g supplements gained an average of 31 g in 8 weeks.

Nothing noteworthy was observed at autopsy except that the females showed less sexual development than the males. The ovaries were small and undeveloped with no ripening follicles, whereas most of the males had moderately well developed testes with microscopic evidence of motile sperms in the cauda epididymis.

VITAMIN G (B₂)

Young rats weaned when 23 and 26 days old averaged 46 and 48 g in weight when placed on the vitamin-G-free diet.

The results of feeding 21 rats cooked green soybeans as the sole source of vitamin G are summarized in table 2 and figure 3.

For these experiments, vitamin B was supplied the rats by feeding daily 4 drops (0.12 to 0.13 g) of tikitiki extract obtained from the Bureau of Science, Manila, P.I.

The fact that the three controls maintained a practically constant weight during the 8-week period following the depletion of vitamin G stores, is evidence that this quantity of tikitiki extract contributes little or no vitamin G to the diet.

Judging from the growth curves, cooked green soybeans may be considered a good source of vitamin G. Seven rats fed daily 2 g of cooked soybeans gained an average of 48 g in 8 weeks and 12 rats fed 1.5 g daily gained an average of 43 g in 8 weeks. The gains were very uniform and there was no flattening of the growth curves after the fifth or sixth week of the test period.

Two rats, whose records are included in table 2 but not in the figure, were fed 4 g of cooked soybeans daily and gained 96 and 99 g during the 8-week test period.

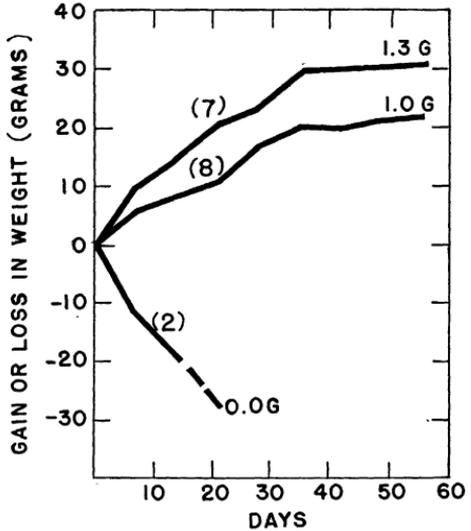


FIGURE 2.—Average gain in weight of groups of young rats fed various amounts of cooked immature soybeans as the sole source of vitamin B₁. The broken line indicates the occurrence of the first death in the control group. The numbers in parentheses show the number of rats used for each test.

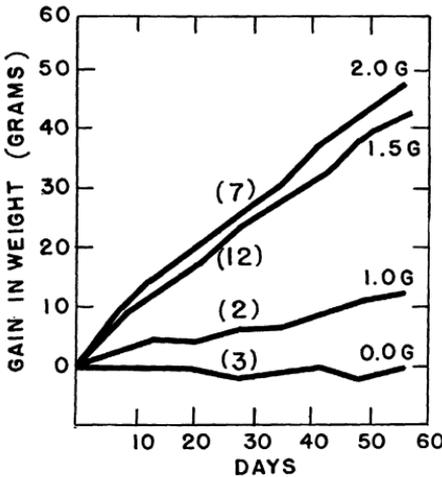


FIGURE 3.—Average gain in weight of groups of young rats fed various amounts of cooked immature soybeans as the sole source of vitamin G (B₂). The numbers in parentheses show the number of rats used for each test.

At autopsy all the rats had abnormally short, soft fur, which in some cases was thin around the head and shoulders. All except one showed varying amounts of blood on nose, paws, and ears, which came from the hair follicles at the base of the whiskers. Only two of the rats showed small lesions. No other symptoms of G avitaminosis were observed.

As in the vitamin B experiments, the females showed poorer sexual development than the males. The ovaries were small without ripe or ripening follicles, but most of the males showed moderately well developed testes and motile sperms.

VITAMIN C

Fourteen standard guinea pigs raised in the nutrition laboratory were used to test the vitamin C potency of cooked green soybeans. The guinea pigs were fed Sherman's (9) scorbutic basal diet plus fresh alfalfa plus the supplements until they ate the soybeans readily. The alfalfa was then discontinued and the soybeans fed to the guinea pigs for the periods indicated below. At the end of the experiment the histological examination of the incisor teeth recommended by Höjer (4) was employed. The results of the experiments are summarized in table 3.

TABLE 3.—Results of feeding various amounts of cooked green soybeans to guinea pigs as the sole source of vitamin C

Guinea pig no.	Weight of supplement fed daily	Period during which supplement was fed	Weights of animals—		Net gain or loss	Gross scurvy at autopsy ¹	Histological examination of teeth, Höjer's rating ²
			When supplement started	At end of experiment			
	Grams	Days	Grams	Grams	Grams		
232-F	0		306	388	82	+++	0.2
234-F		21	296	317	21	tr.	.4
236-F		21	307	256	-51	+	.4
238-F	10	21	296	330	34	tr.	.4
269-M		21	355	436	81	-	.7
267-M		21	302	375	73	-	.8
289-M		21	321	406	85	-	.9
293-M ³		21	301	318	17	+	.4
264-F	12	21	324	364	40	-	.7
295-M		61	335	599	264	-	.5
291-M		21	320	418	98	-	.5
258-F ^c	15	21	298	296	-2	++	.4
254-F		60	304	462	158	-	.7
256-F ^c	20	21	300	313	13	+	.4
252-F		60	315	442	127	-	1.0

¹ SHERMAN, H. C., and SMITH, S. L. (10, p. 173).

² HÖJER, A (4).

³ Animal did not eat supplement satisfactorily.

The animals were somewhat erratic in their response to the feeding of cooked green soybeans as a source of vitamin C; some in each group showed evidence of gross scurvy at autopsy. Guinea pig no. 293-M, fed 12 g, and no. 258-F, fed 15 g, did not eat all of the daily supplement during the last week of the experiment. Guinea pig no. 256-F, fed 20 g, frequently failed to eat the daily supplement immediately after it was given but often left a part of it for 5 to 6 hours or longer. This probably accounts for the fact that these three guinea pigs showed

evidence of gross scurvy, whereas the other animals fed similar daily supplements were protected.

The results of the feeding tests indicate that cooked green soybeans are a poor source of vitamin C, as daily 12-g supplements are required to protect the animals from gross scurvy. Apparently 20 g or more are necessary to protect the teeth from histological changes, but it is difficult to induce guinea pigs to eat this quantity.

SUMMARY

Two varieties of cooked green immature soybeans were analyzed for organic nutrients and for calcium, phosphorus, and iron.

As compared with most vegetables, they had unusually large amounts of protein, fat, calcium, phosphorus, and iron.

Cooked immature soybeans proved to be a very good source of vitamins A, B, and G and a poor source of vitamin C.

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