BEAN SPROUTS AS SOURCES OF VITAMIN C

by

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INTRODUCTION

Bean sprouts are recognized as a valuable source of vitamin C. They are widely used in the Orient, but are little used as human food in this country, although many people prepare oat sprouts for animals. Lately canned Mung bean sprouts have been found in the market, but they are not comparable to the fresh Mung bean sprouts in appearance, crispness, texture, or palatability. Fresh Mung bean sprouts are produced and served in Chinese restaurants in the United States. Seemingly, people in this country associate bean sprouts with chop-suey or chow-mein and have not thought of using them in common dishes, such as in raw salad or as a cooked vegetable. In China and India, bean sprouts are usually cooked, but in the Dutch East Indies and Malay States raw sprouts are used as salad. In the Orient bean sprouts are considered one of the cheapest and commonest of the fresh vegetables. In view of their wide use in the Orient and their low cost, a further study of bean sprouts as a source of vitamin C for the American diet seemed desirable.

REVIEW OF LITERATURE

Hess (7) reviewed the history of scurvy up to 1920 and cited the work of Fürst, who in 1912 reported that dried peas, lentils, and beans were poor in antiscorbutic vitamin, but that these seeds developed antiscorbutic properties when germinated (soaked and allowed to sprout), as shown by feeding experiments with guinea pigs.

Wiltshire (18) compared germinated beans with lemon juice for Serbian soldiers with scurvy. He reported that recovery was at least as rapid for those receiving 4 ounces of germinated haricot beans as for those receiving 4 ounces of fresh lemon juice per day. Seven pounds of beans, dried weight, were soaked 24 hours, germinated for 48 hours at a temperature of 60° to 70° F., and then cooked for 10 minutes to provide portions for 28 patients.

Chick and Delf (4) studied the antiscorbutic properties of sprouted peas and lentils. They reported that after 48 hours of germination at room temperature, the antiscorbutic value of the dry seeds was increased. It is interesting to note that 5 grams (dry weight) sprouted peas or lentils were sufficient to protect the guinea pigs from scurvy, although the basal diet supplied the animals seems open to criticism

in the light of modern work. They also reported that cooking the germinated lentils in water for 15 minutes caused a loss of about 75 per cent of the antiscorbutic value. They stated that raw bean sprouts are eaten in the Dutch Indies and Federated Malay States.

Delf (5) found that 2.5 grams of raw germinated cowpeas fed daily protected guinea pigs from scurvy for 90 days. She also found that 15 to 20 grams of boiled germinated cowpeas, 10 grams of steamed, or 20 grams of simmered germinated cowpeas fed daily, gave protection. She concluded that 20 minutes of steaming or simmering in water to which ammonium carbonate had been added was the best method of cooking the germinated cowpeas.

Santos (15) studied togi, the Japanese name for Mung bean sprouts. Togi were prepared by soaking the beans in water for 24 hours and then allowing them to sprout in the dark for 2 days. He found that 5 grams of fresh togi fed daily protected guinea pigs from scurvy, but togi boiled 10 minutes in a covered vessel fed as 5-gram daily supplements to 2 guinea pigs did not prevent death from scurvy.

Honeywell and Steenbock (8) studied the synthesis of vitamin C in germinated barley. They compared the antiscorbutic properties of barley fed dry, soaked for 24 hours, soaked for the same length of time and germinated in the

dark for 3 days, and soaked for 96 hours, respectively. The soaking was carried on in the absence of oxygen. During the germination the seeds were kept moist and allowed plenty of air. With the soaked, but not germinated, barley as the source of vitamin C the loss in weight and symptoms of scurvy occurred in from 28 to 30 days in the case of the 24-hour samples and in about 37 days with the 96-hour samples. The germinated barley, although practically free from green pigment, afforded complete protection against scurvy. It was concluded that vitamin C, though easily destroyed by oxidation, nevertheless requires oxygen for its synthesis by the germinating seed.

Miller and Hair (13) studied the vitamin content of Mung bean sprouts, using the ordinary market supply in Honolulu. They found that the only sign of scurvy shown by 3 guinea pigs fed 2.5 grams of raw sprouts was a loose tooth in 1 animal. Of the 2 animals on 3 grams of raw sprouts each had a tooth missing or broken. Cooked sprouts were prepared by steaming in a household steamer for 5 minutes. Of the 4 guinea pigs fed 2.7 grams cooked bean sprouts (equivalent to 3 grams raw), 2 showed no sign of scurvy and 2 showed slight scurvy. The authors stated that their investigation was not complete. They concluded that the amount of cooked sprouts needed for complete protection

was probably between 3 and 4 grams. The data obtained indicated that there was considerable destruction of vitamin C even in 5 minutes cooking by the steaming process. In the raw state bean sprouts have a high antiscorbutic value, 180 Sherman units per pound. In the cooked state the bean sprouts had approximately 150 units per pound or a little less. In the raw state Mung bean sprouts had a vitamin C content estimated by the authors to be equal to that of lemon, orange, and tomato juice and when cooked 5 minutes a slightly lower value.

Simonik (16) studied the vitamin C content of germinated legumes, using guinea pigs. He determined the vitamin C content at different stages of germination, from 6 hours to 20 days. He found, after 5 days of germination, 5 grams of sprouts protected the guinea pigs from scurvy, while after 20 days 2.5 grams of sprouts contained the same amount of vitamin C. He demonstrated that beans and peas produced vitamin C 6 hours after wetting, but the protective dose was 20 grams.

Luettmerding (10) found the formation of vitamin C was hastened in wheat and rye by germination in acidified water. He used citric acid and distilled water.

Euler and Klussmann (6) determined the vitamin C content of germinated beans by titration with 2, 6-dichloro-

phenolindophenol and found more vitamin on the 14th day than on the 4th day. On the 4th day of germination, there were 0.083 mg. of ascorbic acid per gram of sprouts; on the 14th day, there were 0.2 mg. of ascorbic acid per gram of sprouts. They advised extraction in the absence of atmospheric oxygen.

Wats and Woodhouse (17) studied the antiscorbutic value of various kinds of sprouted Mung beans and their juices. A daily dose of 3 gm. of sprouted Mung beans protected guinea pigs from scurvy. The filtered juice an hour after being expressed was only slightly active even in a dose of 10 ml., the fall in potency being due to the action of oxidases and peroxidases present.

Bogart and Hughes (3) have studied the vitamin C in sprouted oats using 2, 6-dichlorophenolindophenol. They reported that there was a steady increase in the vitamin C content of oat sprouts up to the 10th day. They found over 90 per cent of the vitamin C was contained in the epicotyl. There was little difference between the vitamin C content of the root and that of the kernel. If there was any difference it was slightly more in the kernel.

Ahmad (1) determined the vitamin C content of many Indian foods by the chemical method. Foods studied were purchased in the markets and were considered typical

products. Reference is made to a few animal experiments with these products for comparison of results. He found that in the sprouts of green Mung beans there were 0.23 mg. ascorbic acid per gram of sprouts. The ascorbic acid value computed from guinea pig experiments was 0.15 mg. per gram. This value for the ascorbic acid content of Mung bean sprouts was higher than for any other sprouted legumes tested.

EXPERIMENTAL

Appropriate temperature, humidity and ventilation are necessary for the germination of beans. The most suitable temperature range is said to be 60° to 70° F. Lower temperatures retard the germination of the beans and growth of the sprouts while higher temperatures hasten the growth but increase moulding and spoilage. The sprouts grown in the dark are white in color or etiolated, whereas those exposed to light are green. Chick and Delf (4) noted with interest that a dose of 7 to 10 gm. of peas germinated in the dark was as efficient as an approximately equal dose of peas germinated under ordinary conditions. This was confirmed by Honeywell and Steenbock (8). Bogart and Hughes (3) as a result of their study of oat sprouts stated that there was no difference in the vitamin C content,

whether the oats were grown in the light or dark. However, Matsuoka (12) worked with barley and stated that the content of vitamin C was increased when grown in the light, as judged by his results from animal experiments. For the present series of experiments, etiolated sprouts were produced, because these have been preferred for human consumption.

The "rag doll" method of sprouting seeds (19) was suggested as suitable for laboratory use and was employed for producing the sprouts of Series I. The "rag doll" method requires a moistened piece of cotton flannel about 10 x 27 inches. The seeds are distributed evenly in the center of the cloth and the two sides are folded over about 2 inches and then the whole is rolled loosely in order to permit air to circulate. The roll or "rag doll" is then put in a place of suitable temperature and kept moistened. This method is suggested for ordinary household use in testing the germination of seeds and requires little attention.

However, the "rag doll" method is not adapted for quantity production of sprouts. In the preliminary work of this study it was found that the sprouts produced were not straight and even in length.

The use of a small "germinator" was next suggested for

growing the bean sprouts. For this a cotton flannel circle, 3 to 4 inches in diameter with wick attached, is supported on top of a quart glass fruit jar full of water. It is supported by a thin circle of paraffin with a hole in the center, through which the wick drops into the water to provide constant moisture and humidity. A clean piece of filter paper is placed on top of the flannel. The seeds to be germinated are placed on the filter paper and covered with an inverted glass funnel. The funnel retains the moisture necessary for germination and also provides for ventilation. Small germinators of this type were constructed and used for sprouting the beans, but proved to be too small for producing sufficient sprouts for the tests. Larger germinators, similar in principle to the small ones, were made and used for the experiments of Series II. Flat tin milk pans 9 inches in diameter were used to hold the water. On top was placed a piece of galvanized iron screen with meshes 0.5 inches square. This screen supported a piece of cotton flannel cut to fit the top of the pan. A wick sewed to the center of the flannel circle passed through the screen into the water. Beans to be sprouted were distributed evenly over the cloth and covered with another milk pan of the same size with holes in it to provide ventilation. The beans sprouted successfully in

these improvised germinators.

Vitamin C (ascorbic acid) determinations were made according to the method of Bessey and King (2). Lemon juice was used in the standardization of the dye solution. The dye indicator, 2, 6-dichlorophenolindophenol, was prepared by dissolving 0.1 gm. of the dye to 200 ml. of warm distilled water. A portion of 5 ml. of freshly prepared, strained lemon juice was titrated with standardized 0.01 normal iodine solution until a permanent blueing of the starch indicator resulted. A separate 5 ml. portion of the lemon juice was then titrated with the dye solution to a permanent pink end-point. As 1 ml. of 0.01 normal iodine solution reacts with 0.88 mg. of ascorbic acid, the ascorbic acid equivalent of the dye solution was calculated in terms of mg. of vitamin C. Trichloroacetic acid solution was used for extracting the bean sprout tissues. Part of the plant tissues was extracted with an 8 per cent acid solution according to Bessey and King (2) and part was extracted with a 3 per cent solution according to McHenry and Graham (11). The experiment showed either concentration gave similar results. The ascorbic acid was determined by extracting a weighed sample (1 to 3 gm.) with trichloroacetic acid, centrifuging, and titrating the clear solution with standardized 2, 6-dichlorophenolindophenol. Duplicate

determinations were made in all cases and blanks were used to check the reliability of methods and reagents. Some trichloroacetic extracts of Mung and A K sprouts were pink. These were titrated with standard iodine solution because it was impossible to use the 2, 6-dichlorophenolindophenol with an end-point of faint permanent pink. According to Bessey and King (2) most plant tissues contain reducing material which reacts with iodine in acid solution but not with the dye. It is the dye titration which corresponds to the results of animal assays. A series of sprouts were titrated with both iodine and dye, to give a factor for translating the results of iodine titrations with ascorbic acid. These results may be less reliable than those obtained with dye directly.

The first experiments (Series I) included the studies undertaken to find beans suitable for sprouting in the laboratory. The varieties tested for germination in Series I by the "rag doll" method were green Mung, Red Kidney, Bayou, Pinto, and Kentucky Wonder beans, Blackeye cowpeas and various kinds of soybeans. The Easycook soybeans which were difficult to secure were obtained from R. H. Monier (14). Other varieties of soybeans were secured through the kindness of Professor J. W. Zahnley, Department of Agronomy. Samples of Kentucky Wonder and Pinto beans and

Blackeye cowpeas were purchased in a grocery store; and another sample of freshly threshed Red Kidney bean and some Bayou beans were obtained from California. The Mung beans were purchased at a Chinese Restaurant which imported directly from China. Mung bean seeds (Phaseolus mungo or P. aureus), also known as green gram beans, are small, round, green beans about 3 mm. in diameter.

Results of the experiments of Series I showed that germination was easiest with the Mung beans. Some of the seeds, particularly those purchased in the grocery store, probably had been in storage for some time and therefore were not suitable for sprouting, as new seeds are essential for germination. Those that did not germinate, moulded and spoiled. Samples of sprouts from the experiments of Series I were used for vitamin C determinations and data are included in Table 1.

For Series II, the new sample of A K soybeans provided by the Department of Agronomy, the Red Kidney beans secured fresh from California and the Mung beans were used. Of the beans tested, these three kinds of beans seemed to be most desirable for sprouting in the laboratory.

Beans to be sprouted were counted and weighed. The sprouts produced were also counted and weighed to secure data on yield of edible material. The edible portion

consisted of the bean sprout with the bean hull removed. Precautions were necessary to prevent evaporation while counting and weighing sprouts. Vitamin C content was determined on the whole sprouts, the beans or cotyledons, including the plumules if present, and stems or radicles. The Red Kidney bean sprouts had long roots which did not seem edible. These were tested separately. Vitamin C was also determined in samples of canned Mung bean sprouts. Reports (16) in the literature suggested that more vitamin C is present if the sprouting is allowed to continue over a period of time. For these experiments, sprouts large enough to be considered desirable for food were studied for their vitamin C potency as well as palatability. The ascorbic acid content of cooked bean sprouts of Series II was also determined. The sprouts were cooked 3, 5, and 15 minutes in improvised steamers, over boiling water. The cooking was carefully timed. Raw and cooked samples were also submitted to a tasting committee. These tasters were not accustomed to the sprouts, and judged them as persons trying new food. The score sheet shown was devised incorporating standards for good sprouts accepted in the Orient.

SCORE CARD FOR BEAN SPROUTS

Signature of Judge _____

Date _____

E = Excellent F = Fair
G = Good P = Poor

		Remarks	Sample Number				
Appearance	1. Sprouts should not be too thin, too long or too short.						
Texture	2. Sprouts should be crisp						
	3. Sprouts should be tender						
Succulence	4. Sprouts should be juicy						
Palatability	5. Sprouts should have a desirable flavor -- not too strong.						

Which sample do you prefer?

1st choice _____
2nd choice _____
3rd choice _____
4th choice _____

DISCUSSION

Table 1 summarizes data obtained from the experiments of Series I. For these experiments the beans were sprouted by the "rag doll" method. This method seemed to produce crooked sprouts, probably due to crowding in the roll. The sprouts were not uniform in size. In all cases the hulls of the beans were removed and the remainder of the sprouts used for the determinations.

Highest figures for ascorbic acid content per gram of sprouts were obtained for the Blackeye cowpeas, with averages of 0.20 to 0.23 mg. per gram. Ahmad (1) reported results from a series of experiments and found only green Mung sprouts to be this high, 0.23 mg. per gram. Other legume sprouts studied by Ahmad contained not more than 0.15 mg. ascorbic acid per gram. In spite of the high vitamin C content, the Blackeye cowpea sprouts did not seem promising for human food, because the sprouts were unusually short in proportion to the size of the beans.

Other sprouts tested in this series contained one-half to two-thirds as much ascorbic acid per gram as did the Blackeye cowpea sprouts. Sprouts of different ages were tested, to learn whether or not the vitamin C content changed with age. Sprouts were studied at the earliest

Table 1. Vitamin C in Sprouts of Series I ("rag doll" method)

Kind of beans	Age in days	Average mg. ascorbic acid per gm. of sprouts		No. of experiments	Remarks
Blackeye cowpeas	7	0.23)		3	Sprouts short and thick, longest sprouts about 2"
	8	0.22)	0.22	3	
	9	0.20)		1	
Kentucky Wonder beans	7	0.11)		2	Sprouts short, many undesirable roots
	8	0.14)	0.11	2	
	9	0.09)		1	
Mung beans	7	0.17)			
	8	0.17)	0.17	2	Sprouts good, $1\frac{1}{2}$"to 2" long
				4	
Pinto beans	7	0.13)		3	Sprouts short and thick, many roots, $\frac{1}{2}$" to 2" long
	8	0.13)	0.12	4	
	9	0.11)		1	
A K soybeans (1st sample)	7	0.12)		4	Sprouts poor, longest 2" to 4"
	8	0.11)	0.12	4	
Hongkong soybeans	6	0.13)		1	Sprouts moulded, $1\frac{1}{2}$" to $2\frac{1}{2}$" long
		0.15)	0.14	4	
Easycook soybeans	7	0.11		1	Said to be excellent beans, sample available did not sprout well - moulded
Illini soybeans	7	0.11		1	Few sprouted, others spoiled
Manchu soybeans	5	0.12)		1	Sprouts moulded, $1\frac{1}{2}$" to 3" long
	6	0.10)		1	
	7	0.11)	0.12	5	
	8	0.14)		4	

stage which seemed suitable for human food. Determinations were made on successive days until the sprouts were too much developed to be desirable for human food. For instance the sprouts would become too long and rangy, the plumules prominent, and the roots conspicuous. Data obtained for sprouts of different ages were less reliable than anticipated, because the growing conditions, especially the temperature, could not be controlled exactly. Sprouts 9 days old in one lot might be about the same size as sprouts 7 days old in another lot. As mentioned above, a low temperature retarded the growth and a high temperature hastened the growth but caused moulding. The Red Kidney beans obtained from the grocery store moulded and did not sprout, so could not be used in the experiments. The Mung beans are most easily sprouted under various temperatures; none moulded at the higher temperatures.

Kentucky Wonder beans produced short thick sprouts with many long roots. The sprouts of the Pinto beans were similar. The amount of sprouts produced seemed too small in proportion to the size of the beans. If served for food these products would consist largely of beans or cotyledons rather than of the tender, succulent stems.

Soybean sprouts are used in the Orient and were included in these experiments. Results from 5 varieties of

soybeans sprouted are given in table 1. According to Monier (14) Easycook soybeans may be used to produce sprouts for salads and the like. The samples of Easycook soybeans available did not germinate well and could not be sprouted successfully. They seemed to mould easily. It was difficult to secure enough samples of sprouts for the titration determinations. The Illini soybeans available behaved in much the same way. Extensive experiments with these varieties were not possible with the samples of seeds available. The other varieties of soybeans used produced the best sprouts under the laboratory conditions of this experiment. A new sample of this variety was obtained for further sprouting.

Table 2 presents results of experiments with Red Kidney bean sprouts produced in the large improvised germinators using the new supply of beans from California. These beans were thought to be similar to the haricot beans used by Wiltshire (18) to prepare sprouts for Serbian soldiers needing scurvy-preventing food. The vitamin C contents of the raw sprouts, stems, cotyledons and roots were compared with the vitamin C contents of the cooked products. Steaming for so short a time as 3 minutes caused loss in vitamin C content. There was some vitamin C present after cooking as much as 15 minutes, although 3 to

Table 2. Vitamin C in Red Kidney Bean Sprouts

	No. of experiments	Whole sprouts	Stems	Cotyledons	Roots	Remarks
		mg. ascorbic acid per gm.				
Raw	3	0.18	0.14	0.13	0.18	Many roots, sprouts large
Cooked 3 minutes	2	0.14	0.10	0.12	0.13	Juicy
Cooked 5 minutes	2	0.12	0.10	0.10	0.06	Juicy
Cooked 15 minutes	2	0.07	0.05	0.09	0.03	Over-cooked

5 minutes appeared to be sufficient for a palatable, nutritious cooked product. Long cooking destroys the crispness and succulence of the sprouts and so is undesirable from the standpoint of palatability as well as from that of vitamin content. The vitamin C seemed to be distributed throughout the entire sprout.

These Red Kidney beans sprouted in the laboratory produced, on the average, 3.1 gm. sprouts without hulls for each gram of dry beans used. Wiltshire (18) reported that 4 ounces of dry haricot beans, when sprouted, were at least as effective in curing scurvy as 4 ounces of lemon juice. That is, he believed the sprouts from a given weight of dry beans to be as active in curing scurvy as an equal weight of lemon juice. Bessey and King (2) gave 0.57 mg. ascorbic acid per gram as the average for lemon juice. This is similar to the ascorbic acid found in the present experiments in the sprouts from 1 gm. of beans, for 3.1 x 0.18 (average figure for whole raw sprouts) equals 0.56 mg. ascorbic acid. However, Wiltshire had the sprouts cooked before serving, which makes exact comparison impossible.

Table 3 gives figures obtained from the experiments with A K soybeans of the fresh lot, sprouted in the large germinators. Efforts were made to keep conditions of

Table 3. Vitamin C in A K Soybean Sprouts

	No. of experiments	Whole sprouts	Stems and roots	Cotyledons	Remarks
		mg. ascorbic acid per gm.			
Raw	9	0.13	0.12	0.12	2" to 4" long, some too thin
Cooked 3 minutes	7	0.08	0.03	0.10	Tender, juicy
Cooked 5 minutes	7	0.07	0.03	0.08	Tender, juicy
Cooked 15 minutes	7	0.04	0.03	0.06	Dark, shriveled

germinations uniform throughout the experiments but certain variations were unavoidable. Cold weather made it difficult to maintain constant temperature in the room used for germination. As a result, some sprouts were too small or too thin to meet the requirements of good edible sprouts. The variations in time and temperature of sprouting may account for some of the variations in the ascorbic acid content per gram of sprouts. The average for the whole raw A K soybean sprouts, 0.13 mg. ascorbic acid per gram, was lower than that for sprouts of Red Kidney beans. One gram of dry A K soybeans yielded 2.5 gm. sprouts, containing 0.33 mg. ascorbic acid, according to the data obtained from this experiment.

A K soybean sprouts cooked 3 minutes contained on the average 0.08 mg. ascorbic acid per gram. When cooked 5 minutes they contained on the average 0.07 mg. ascorbic acid per gram and when cooked 15 minutes contained only 0.04 mg. ascorbic acid per gram. Cooking as much as 5 minutes, caused the loss of more than half the vitamin C content of the sprouts while even 3 minutes of cooking caused an appreciable loss.

Table 4 gives figures obtained from the Mung bean sprouts. Variations in conditions of germination caused less difficulty with the Mung beans than with others used.

Table 4. Vitamin C in Mung Bean Sprouts

	No. of experiments	Whole sprouts	Stems and roots	Cotyledons	Remarks
		mg. ascorbic acid per gm.			
Raw	9	0.17	0.12	0.17	Sprouts 1½" to 3½" long
Commercially canned	1	0.01			1½" to 3" long, soft, over-cooked
Cooked 3 minutes	8	0.10	0.08	0.11	Tender, juicy
Cooked 5 minutes	8	0.08	0.07	0.09	Tender, juicy
Cooked 15 minutes	8	0.06	0.03	0.07	Dark, overcooked

Even when the temperature dropped the bean sprouts were in good condition although growth was retarded. It was always possible to secure thick, crisp, and tender sprouts. Slow and retarded growth may however, account for variations in ascorbic acid contents of different lots. The average ascorbic acid content per gram of fresh sprouts was 0.17 mg. One gram of dry Mung beans yielded 4.18 gm. sprouts. The commercially canned sprouts tested contained little ascorbic acid, the figure obtained being 0.01 mg. per gram. Steaming the fresh sprouts for 3 minutes caused considerable loss of vitamin C and half was lost with 5 minutes steaming. About one-third of the vitamin C content remained after about 15 minutes of cooking.

Data from the judging sheets are assembled in table 5. The following equivalents (9) were used in evaluating the scores:

E+ = 93%	F+ = 73%
E = 90%	F = 70%
E- = 87%	F- = 67%
G+ = 83%	P+ = 63%
G = 80%	P = 60%
G- = 77%	P- = 57%

Average scores were computed for each product presented to the judges. The judges often expressed preferences for the cooked bean sprouts. The raw sprouts were usually listed as the last choice. However the total score

Table 5. Average Scores for Judging Sheets

Sample	No. of experiments	No. of judging sheets	Appearance	Texture		Succulence	Palatability	Total score
				Crispness	Tenderness			
Red Kidney								
Raw	3	11	72	81	83	77	71	384
Cooked 3 min.	3	11	75	76	78	77	84	390
Cooked 5 min.	3	11	72	75	78	74	80	379
A K								
Raw	5	22	73	74	77	75	71	370
Cooked 3 min.	5	22	72	74	79	77	78	380
Cooked 5 min.	5	22	73	73	78	75	76	375
Mung								
Raw	7	28	75	82	77	79	74	387
Cooked 3 min.	7	28	75	79	79	78	77	388
Cooked 5 min.	7	28	74	76	80	76	78	384

for the Red Kidney bean sprouts served raw was about half way between the scores for those cooked 3 minutes and those cooked 5 minutes. The total scores were similar for the Red Kidney bean sprouts served raw or cooked. For crispness and tenderness, the raw Red Kidney bean sprouts ranked highest, while for palatability, the cooked sprouts ranked higher.

The judges preferred the cooked A K bean sprouts and usually rated the raw sprouts as last choice. The average scores were similar but the total average was a little higher for the sprouts cooked 3 minutes than for the others.

The raw Mung bean sprouts were considered by most of the judges less palatable than the cooked sprouts. However there was little difference between the average scores of the raw and cooked bean sprouts. The rating of the judges showed no outstanding differences.

Many of the judging sheets carried the remark that the raw sprouts were strong or too raw in flavor. On the other hand, the cotyledons of the sprouts were often said to have a nut-like taste. The judges liked the bean sprouts although they were not accustomed to eating this food. Had the sprouts been seasoned and well prepared, they would have been appreciated more.

It appears that bean sprouts could be used as inexpen-

sive sources of vitamin C. One cent's worth of dry Mung beans, at 15 cents per pound, would, when sprouted, produce 20 mg. of ascorbic acid, equivalent in vitamin C content to 35 gm. of lemon juice. One cent's worth of dry Red Kidney beans, at 4 cents per pound, would, when sprouted, produce 57 mg. of ascorbic acid, equivalent in vitamin C content to 96 gm. of lemon juice. One cent's worth of dry A K soybeans, at 2 cents per pound, would, when sprouted, produce 71 mg. of ascorbic acid, equivalent in vitamin C content to 125 gm. of lemon juice.

SUMMARY

Several varieties of beans were germinated in the laboratory and the sprouts, both raw and cooked, tested for palatability and also for ascorbic acid content using 2, 6-dichlorophenolindophenol.

The results show that:

1. A K soybeans and Mung beans produced the most satisfactory sprouts under the conditions of the laboratory. Mung beans sprouted well even when conditions could not be well controlled.

2. The sprouts of Blackeye cowpeas contained 0.22 mg. of ascorbic acid per gram of raw sprouts, the highest figure found in these experiments. The sprouts of Red Kidney or

haricot beans containing 0.18 mg. ascorbic acid per gram, ranked next. The sprouts of Mung beans and A K soybeans contained 0.17 and 0.13 mg. ascorbic acid per gram respectively. The vitamin C content of the other raw bean sprouts tested ranged down to 0.11 mg. of ascorbic acid per gram of sprouts.

3. Bean sprouts cooked 3 minutes lost at least one-fourth of the vitamin C content. Some additional loss occurred when the cooking time was increased to 5 minutes. Sprouts cooked 15 minutes lost more than one-half of the vitamin C.

4. The judges preferred the sprouts that were cooked 3 minutes and next those cooked 5 minutes. Cooking as long as 15 minutes was not desirable. It caused the sprouts to lose their crispness and to become discolored, in addition to lessening the vitamin C content. The judges commented that the flavor of the raw sprouts was strong.

5. It appears that bean sprouts could be used as inexpensive sources of vitamin C. One cent's worth of dry Mung beans, at 15 cents per pound, would, when sprouted, produce 20 mg. of ascorbic acid, equivalent in vitamin C content to 35 gm. of lemon juice. One cent's worth of dry Red Kidney beans, at 4 cents per pound, would, when

sprouted, produce 57 mg. of ascorbic acid, equivalent in vitamin C content to 96 gm. of lemon juice. One cent's worth of dry A K soybeans, at 2 cents per pound, would, when sprouted, produce 71 mg. of ascorbic acid, equivalent in vitamin C content to 125 gm. of lemon juice.

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