VITAMIN CONTENT OF SOME MATURE AND GERMINATED LEGUME SEEDS[1]

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(WITH ONE FIGURE)

In earlier papers we have reported observations made on some of the changes in B vitamins associated with germination of various kinds of edible seeds (**3, 4**). This work has been continued with seeds of high protein content, including garden pea, Mung bean, and several strains of soybean. Inasmuch as sprouted legume seeds possess protein of high biological value (**6**), and since their palatability is often improved during germination, these materials appear to deserve further serious consideration as a potential source of nutritious food which could easily be made available in large quantities. The present report is concerned with determinations of thiamine, riboflavin, pyridoxine, niacin, pantothenic acid, inositol, vitamin B_c, biotin, and ascorbic acid in mature dry and freshly sprouted seeds of *Pisum sativum* variety Canner King, *Phaseolus aureus* (the Mung bean commonly used in chop suey), and 7 varieties of field type soybean belonging in the species *Soja max*.

Methods

The general methods of investigation have been reported in our earlier papers. Seeds were germinated at 25° C. on moist filter paper in large Petri dishes kept in a darkened room. In most of our experiments seeds were treated with a solution of filtered calcium hypochlorite (5 gm. in 150 ml. H_2O) for 1 hour in order to avoid contamination with microorganisms during germination. One series was sprouted without preliminary treatment with chlorine to determine whether changes in vitamin content would occur similar to those observed in the chlorine-treated seeds. These seeds were washed for 1 hour in running tap water prior to transferring them into Petri dishes.

Various stages of germinated seeds were obtained for analyses on the same day by the simple expedient of soaking the dry materials at 4-, 3-, 2-, and 1-day intervals prior to the date set for the final sampling. Samples of the fresh materials, consisting of 5 individuals of pea and soybean and 20 seeds or seedlings of Mung bean, were taken both for direct assay and for the determination of the constituent dry matter. Weighed amounts of the fresh sprouting seeds were ground in acetate buffer solution adjusted to pH 4.5 for the purpose of obtaining extracts to be assayed for B vitamins.

Dry preparations of papain and Taka-diastase were added to provide each enzyme in amount equivalent to approximately 4 per cent. of the dry weight of the sample. Digestion was allowed to proceed at 37° C. for 24 hours, using a few drops of benzine in the stoppered flasks to inhibit growth

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TABLE I

THE B VITAMIN CONTENT OF DRY AND SPROUTED SOYBEANS AND MUNG BEAN. VALUES ARE EXPRESSED AS MICROGRAMS PER GRAM OF DRY MATTER IN DUPLICATE SETS OF DETERMINATIONS

VARIETIES OF BEANS	THIAMINE		RIBOFLAVIN		PYRIDOXINE		NIACIN		PANTOTHEN		INOSITOL		B_c		BIOTIN	
	DRY	SPROUTED	DRY	SPROUTED	DRY	SPROUTED	DRY	SPROUTED	DRY	SPROUTED	DRY	SPROUTED	DRY	SPROUTED	DRY	SPROUTED
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Peking	15.7	19.6	3.8	5.0	13.3	13.6	21.4	29.9	36.6	34.4	2436	3729	1.89	0.73	0.85	1.10
	16.7	18.0	3.7	4.8	12.0	12.8	22.3	33.2	35.9	34.4	2436	3839	1.83	0.69	0.94	1.08
Manchu	16.0	21.9	3.4	6.0	11.1	17.7	20.3	42.8	19.5	33.1	1855	3944	1.69	1.29	0.76	1.76
	17.7	19.0	3.3	5.3	11.6	16.1	21.7	40.0	19.0	28.6	2086	3441	1.76	1.24	0.80	1.64
Mukden	17.0	14.9	3.4	7.4	11.2	15.2	20.2	46.0	20.3	30.3	2311	3336	1.74	1.03	0.79	1.50
	17.0	17.7	3.4	7.0	10.8	16.6	20.0	48.0	19.6	30.6	2055	3677	1.61	1.37	0.85	1.78
Lincoln	18.9	17.6	3.6	4.9	11.1	15.9	21.3	35.1	22.5	26.8	2549	3340	1.88	1.39	0.80	1.38
	16.5	13.8	3.4	5.1	11.1	14.1	20.0	37.8	21.5	37.8	2516	2852	1.94	1.08	0.70	1.46
Dunfield	13.9	11.9	3.4	4.5	11.5	14.4	20.6	31.2	15.8	18.8	2298	2524	2.01	1.13	0.89	1.49
	13.1	12.5	3.4	4.7	11.3	14.7	20.5	33.7	15.9	22.5	2176	2959	2.07	1.09	0.85	1.54
Illini	18.5	16.8	3.3	4.9	12.6	15.8	21.1	33.4	19.6	26.3	2500	3505	2.16	1.07	0.85	1.74
	18.7	17.9	3.3	5.1	12.1	16.4	20.7	32.2	19.5	26.7	2457	3581	1.99	0.97	0.83	1.72
Anwei	13.4	12.4	4.5	7.0	12.7	17.9	25.9	40.7	18.1	29.9	2276	3383	2.31	0.88	0.70	1.74
	14.0	13.3	4.3	6.3	12.9	16.8	23.2	38.4	17.1	27.3	2112	2877	2.07	1.13	0.63	1.41
Mung	8.8	8.2	3.2	14.1	11.8	13.6	23.4	64.7	16.3	32.5	1812	3635	2.55	1.88	0.25	0.59
	8.2	8.6	2.8	14.7	11.0	15.1	22.8	68.3	16.5	34.8	1887	3663	2.39	2.05	0.20	0.78

of microorganisms. The digested samples were heated in steam at 100° C. for 30 minutes, adjusted to pH 5.5, made to standard volume, and filtered through "supercel" in a Büchner funnel. Riboflavin, niacin, and pantothenic acid were tested with *Lactobacillus casei* in accordance with methods published by R. J. WILLIAMS, *et al.* (**11**). Vitamin B_c was determined with *L. casei* according to the procedure of LANDY and DICKEN (**8**). Pyridoxine was assayed with a yeast growth method employing *Saccharomyces oviformis* (**2**). Biotin was tested with the yeast *S. cerevisiae* 139 using the general method outlined by SNELL, EAKIN, and WILLIAMS (**10**). Inositol was determined with the yeast *Kloeckera brevis* (**5**). Thiamine was assayed by the Phycomyces growth method (**1**). Ascorbic acid was measured by the colorimetric procedure recommended by PEPKOWITZ (**9**). Reduced ascorbic acid was determined directly in the sample ground in metaphosphoric acid, and total ascorbic acid was measured after reduction with H_2S and subsequent displacement of this gas by means of nitrogen (**7**).

Results

The results obtained in duplicate assays for the B vitamins in 7 varieties of soybean and in Mung bean, all treated with chlorine at the time of soaking, are presented in table I. Among the soybeans, values for thiamine appear to be somewhat lower in the varieties Dunfield and Anwei than in the other strains. The thiamine content of Mung beans appears to be considerably less than that found in soybeans. No great change in thiamine occurred during germination of the different kinds of seeds listed in the table.

The riboflavin content was about the same in all varieties of mature soybean with perhaps somewhat higher values for the variety Anwei. During germination, increases in riboflavin were observed in all varieties. Sprouted Mung beans contained almost five times as much riboflavin as the dry mature beans. No great differences in pyridoxine were noted among the various kinds of dry beans; some increases in this vitamin appear in the germinated seeds.

The niacin content is almost uniform throughout the list of dry bean seeds; appreciable gains in niacin were observed in the sprouted materials. The niacin in 4-day-old seedlings compared with nonsprouted seeds approximately doubled in Manchu, Mukden, and Anwei varieties. Sprouted Mung beans almost trebled in niacin content. Pantothenic acid, inositol, and biotin appear to increase in nearly all the sprouted materials, but vitamin B_c is reduced appreciably.

The results of a series of determinations made on germinating seeds of Pisum, Phaseolus, and Soja not treated with chlorine are shown in figure 1. Increases in both reduced and total ascorbic acid were observed in all three seeds, but the increase of total ascorbic acid in sprouted Mung beans was outstanding. Niacin increased during germination in both soybean and Mung bean, but the highest values for this vitamin were observed in sprouted

peas. Peas and Mung beans were notable also for their increases in pantothenic acid during germination. Riboflavin increased in the sprouting seeds of all three, but the highest value occurred in Mung bean sprouts.

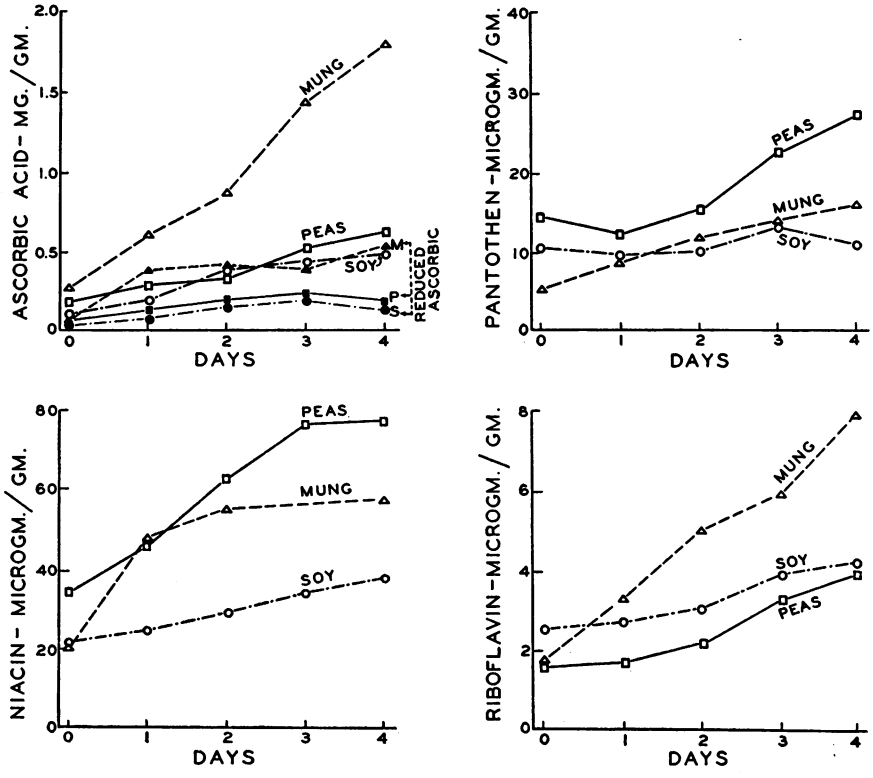

FIG. 1. Vitamin content of mature and sprouted Canner King peas, Mung beans, and Anwei soybeans at 1, 2, 3, and 4 days after soaking in water.

Discussion

Appreciable gains in the concentration of total ascorbic acid, riboflavin, and niacin are associated with germination of peas, soybean, and Mung bean. The calculated changes in dry matter during germination are too small to account for the observed increase of vitamins in these sprouted materials. While some of the B vitamins show increases, values for thiamine generally remain unchanged, and vitamin B_c appears to decline somewhat in these sprouting seeds. The mechanism by which the concentration of some vitamins is augmented in the processes of germination is unknown. It seems reasonable to suppose, however, that increased amounts of vitamins, such as riboflavin and niacin, which are known to be parts of important enzyme systems in intermediate metabolism, might have a profound influence upon the supply of energy in growing tissues of seedlings.

The significance of such data for human and animal nutrition need hardly be stressed. Our investigations indicate that marked increases of

important nutritive substances occur during the sprouting of leguminous and many other kinds of edible seeds. Among the many varieties of soybean which we have used in germination experiments, the garden varieties when sprouted seem to be less satisfactory from the food standpoint than the field types reported in this paper. Among the field varieties the small-seeded Anwei germinated almost as readily as Mung beans. The possible use of sprouted peas, beans, and other seeds in canning and preparation of dehydrated foods would enable these industries to operate on a 12-month basis. If the food value of germinated seeds is to be judged by their content of vitamins and readily available amino acids, then it appears that the common use of sprouts in the diets of Oriental peoples rests on a sound nutritional basis and should be introduced on a wide scale among Occidentals. It is hoped that the data reported here may have significance in academic studies on growth processes of plants and practical value in connection with the use of sprouted seeds for preparing high quality processed foods.

Summary

Microbiological assays were made for thiamine, riboflavin, pyridoxine, niacin, pantothenic acid, inositol, vitamin B_c, biotin, and ascorbic acid in mature and sprouted seeds of *Pisum sativum*, *Phaseolus aureus*, and 7 varieties of *Soja max*. On a dry weight basis, niacin, riboflavin, and ascorbic acid increase greatly during germination. Certain other vitamins show small gains, thiamine generally remains unchanged, and vitamin B_c appears to decrease.

Possible significance of the results for studies on growth processes of plants and in relation to the use of sprouted seeds for preparing high quality processed foods is discussed briefly.

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