NUTRITIVE PROPERTIES OF THE MUNG BEAN.*

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(Received for publication, August 25, 1927.)

The growing popularity of chop suey and other articles of diet which contain as their principal constituents the dry or germinated mung bean, lends an interest to the nutritional value of this bean. From a commercial standpoint, this interest is enhanced by the possibility of its growth in certain semiarid sections of this country where the short growing period makes the production of many of the popular articles of diet, for both man and animal, impossible.

The mung bean is probably a native of India, but its production is now common throughout all southern Asia and other tropical countries. Its growth in this country has not progressed far beyond the experimental stage, and its use as an article of diet for both man and animals has not been sufficiently extensive to lead to any definite conclusions.

The literature makes reference to a few reports in regard to certain chemical and nutritional properties, largely of the foreign grown bean. Embrey (1) refers to its use as an article of table diet in Asiatic countries. Santos (2) reports that it contains vitamin B, while Bowman and Yee (3) state that they prepared vitamin B crystals from this source. Johns and Waterman (4) extracted certain protein fractions and made a study of their nitrogen distribution. A further review of the literature failing to reveal any studies in connection with the nutritional value of the protein or vitamins of the seed, an attempt was made, using biological methods, to determine these properties. Any seed so rich in protein and capable of being grown in the short growing season of some of our hot, dry sections, if possessing a well balanced amino

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acid distribution and a good source of vitamins, would prove to be a valuable supplement to the diet often lacking in variety in these sections of our country. Since the completion of this work an article by Tso (5) reports a study of its protein utilization.

EXPERIMENTAL.

In the nutritional tests, albino rats were chosen as experimental animals due to the well established growth curves in connection with deficiency disturbances as well as their short reproductive period. It has been observed that the full test of a ration's deficiency is most clearly recognized in the response of the second and third generations.

The rats used were approximately 1 month of age, chosen from average sized litters. The growth period, age of reproduction, number of young reared, as well as the percentage of young weaned of this particular strain, have been under observation over a period of several years. In making tests the animals were housed in circular metallic cages, four or more animals to the cage, so selected as to be as similar in size, age, and litter origin as possible. The usual precautions in the preparation of pure rations, weekly weighings and examinations, and cleanliness were observed throughout the tests.

The mung beans used in these tests were solid green seed of a dwarf variety grown on the experimental plots of the Agronomy Department of this institution. For all feeding experiments they were ground fine, and for chemical analysis further pulverized until the total quantity would pass through a 60 mesh sieve. A proximate chemical analysis gave the following results:

	per cent		*per cent*
Protein	23.31	Fat	1.02
Water	9.31	Fiber	3.64
Nitrogen-free extract	59.85	Ash	2.87

A comparison of these figures with those of Embrey (1), reported in his studies of the Chinese mung bean, shows that the American grown seed is somewhat superior. The protein content being of especial interest, a further chemical analysis was made to ascertain whether the nitrogen distribution was complete. For this study the method of Hamilton, Nevens, and Grindley (6) was followed with a few minor modifications. The fractions so obtained are given in Table I.

Previous experiments carried out by numerous investigators have demonstrated that the proteins of a single cereal are usually not satisfactory for normal growth and reproduction unless supplemented with proteins or amino acids from other sources. This is due to the fact that certain amino acids are usually absent or deficient even though the total protein content is high. The protein content of the mung bean is high, as shown above, comparing favorably with that of the velvet bean. We were therefore interested in determining whether the amino acid distribution

TABLE I.

Distribution of Nitrogen in Mung Bean Hydrolysate.

Fraction.	Percentage of total nitrogen.
Total N in sample	3.73
Ether-alcohol-soluble N	None.
Alkali-insoluble N	4.71
N in hydrolyzed sample	93.80
" lost in hydrolysis	0.49
Amide N	6.41
Humin "	3.84
Cystine N.*	1.62
Histidine N.*	6.76
Arginine N.*	13.51
Lysine N.*	12.81
Total monoamino N	49.10
" diamino and cystine N	34.70
" N recovered	94.05
" " accounted for	98.76

* Corrected for solubility of phosphotungstic precipitates.

was more equitably represented than in other members of the bean family, a group possessing a high protein content but unfortunately usually a poor balance of amino acids.

Experiments were planned fully to check the character of this particular protein. The rations used in this study contained 60 per cent of the bean, representing approximately 14 per cent protein. Provisions were made that the proper amount of salts and vitamin should be added to supplement any deficiency other than amino acids, previous investigation having demonstrated that the ions sodium, calcium, and chlorine are usually limited in

most seed. Vitamin A is also usually deficient in these seeds for optimum development.

A second set of experiments was planned by using the optimum protein level found in the preceding experiments, to investigate the vitamin content of the seeds by omitting first one and then another vitamin and observing the result to establish the vitamin content of the seed alone.

A third set of experiments was carried out to determine whether inorganic ions other than sodium, calcium, and chlorine might be deficient. A detailed statement of these rations is shown in a condensed form in Table II.

Ration I as indicated in Table II consisted of 60 per cent ground mung bean supplemented only with 1 per cent of sodium chloride

TABLE II.

Ration No.	I	II	III	IV	V	VI	VII	VIII
Mung bean	60	60	60	60	93.5	92.5	80	80
Starch	38	35	36.5	30			15	18
NaCl	1	1		1			1	1
$CaCO_3$	1	1		1			1	1
Cod liver oil		3		3	3	3	3	0
Salt Mixture 185.*			3.5		3.5	3.5		
Extract of wheat embryo				5				
Cystine						1		

* McCollum, E. V., and Simmonds, N., *J. Biol. Chem.*, 1918, xxxiii, 63.

and a similar amount of calcium carbonate to which dextrin was added to make the entire up to 100 parts. This practice permits the variation of various supplements without altering the amount of seed present. Ration II adds a further supplement of vitamin A in the form of cod liver oil. Ration III replaces sodium chloride and calcium carbonate with 3.5 per cent of McCollum's Salt Mixture 185, while Ration IV contains both. Ration V contains yeast as a source of vitamin B, a deficiency not to be expected in a seed fed at this level. The other rations carried higher levels of the bean protein to ascertain whether certain amino acids, evidently somewhat deficient in a 60 per cent level, might be adequately provided in a larger percentage of seed. Cystine has many times proved to be the limiting factor in many rations, and

for this reason this amino acid was added to Ration VI. The most characteristic results of growth, reproduction, and rearing of young, produced by these rations, have been consolidated and are presented in Table III.

An investigation of Table III indicates that 14 per cent of protein from the single source as used in Ration I gave continued growth to maturity; the mothers gave birth to young, many of which were weaned. The growth even of the first generation was somewhat retarded, it is true, but this condition has been obtained with practically all rations containing protein from only one variety of seed.

To determine whether this result might be due to vitamin or salt deficiency, it is necessary to examine the results of other

TABLE III.

Ration No.	No. of males.	No. of females.	No. of litters.	No. of young.	No. that lived.	No. that died.	No. consumed.	Growth.
II	2	2	2	10	3	7	6	+++
I	2	2	2	11	11	0	0	+++
III	1	3	2	11	6	5	0	+++
IV	3	1	2	11	6	5	5	+++
V	3	1	1	8	7	1	0	+++
VI	1	2	2	10	10	0	0	++++
VII	2	3	3	18	16	2	0	+++
VIII	2	3	4	21	20	1	0	+++

++++ represents normal growth of young in the growing colony.

rations. Ration II, containing vitamin A in the form of cod liver oil, did not prove to be superior to Ration I, containing no such supplement, indicating that this bean is superior to most of our cereals, in that vitamin A is present in amounts necessary for normal growth. Ration III, having a vitamin B supplement, gave no better results. This was to be anticipated, as 60 per cent of most seeds contains an adequate amount of vitamin B for normal development. (It had previously been demonstrated by Honeywell and Steenbock (7) that the beans, while dry, were devoid of vitamin C but became an excellent source of that substance upon germinating.) The addition of a complete salt mixture showed no decided advantage. It then becomes evident

that while the bean is superior to many seeds, and especially most beans, it is either lacking in certain amino acids, or else they are present in such small amount that 60 per cent of the bean furnishes insufficient amount for optimum maintenance. Ration V, which contains 93.5 per cent of the bean (21.5 per cent protein), while somewhat better in its results, is still lacking in its ability to produce normal development. When cystine was added, the ration was improved as evidenced in the superior maintenance of the young, for with this ration reproduction was obtained to the third generation. The somewhat retarded growth and lack of smoothness of fur marked the ration as being somewhat inferior to the mixed ration fed the stock animals. The data do indicate that the protein is superior to that of many members of the bean family. Its vitamin content is superior to that of most cereals, in that vitamin A is more adequately provided.

TABLE IV.

Ration No.	Bean, 80 per cent.	Cod liver oil.	Salts.	Starch.
X	Raw.	3	3.5	13.5
XI	Heated 1 hr.	3	3.5	13.5
XII	" 2 hrs.	3	3.5	13.5
XIII	" 3 "	3	3.5	13.5

Effect of Cooking.

Inasmuch as beans for human consumption are usually cooked before they are eaten, further experiments were planned to determine the effect of heating on the utilization of the protein. In these cases the beans were autoclaved at 15 pounds pressure for 1, 2, and 3 hours, and then dried. Vitamin A was added, because heating at these temperatures would undoubtedly injure this constituent. Table IV indicates the compositions of rations used in these determinations.

Ration X, which was practically a repetition of ration VII gave similar results. Heating for 1 hour seemed to indicate a slight improvement of utilization. Ration XIII in which the seed had been heated for 3 hours was somewhat less satisfactory in promoting growth than either the raw or less heated lots. This is an observation previously noted by us in regard to heating

other foods. A short heating period may aid, but long exposure seems to be injurious to the nutritive properties of the protein. This decrease in nutritive value is not to be accounted for by vitamin destruction, as vitamin A was added to all rations, and 3 per cent of yeast incorporated into Rations XII and XIII during the last 4 weeks gave no evidence of accelerating the rate of growth.

Seasonal Variation of Mung Bean.

Unfortunately, the seeds of this plant do not mature uniformly, and consequently many of the riper seeds shell off before the unripe are ready for harvest. Naturally, this loss would reduce the

TABLE V.

Variety.	Age.	Ash.	Protein.	Ether extract.	Fiber.	Non-filterable extract.
	days	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Standard	91	9.77	21.82	2.60	22.98	42.83
"	98	8.44	21.54	2.41	24.00	43.49
"	112	8.32	19.71	2.56	27.04	42.27
Dwarf	91	8.16	16.83	2.44	22.44	50.00
"	98	9.05	16.99	2.95	21.13	49.88
"	112	9.17	18.92	2.87	20.65	48.39

value of the crop. For this reason, it was suggested that possibly the most economical method of handling would be to harvest the plant at some premature stage. The percentage of protein on a dry weight basis does not change much in the last days of growth. The beans after drying could be threshed and the plants remaining used as fodder for animals. With this in mind, an approximate analysis of the whole plant at various stages of growth was made, to determine the most desirable time of harvesting. Table V contains the analysis of two varieties of the mung bean plant, at different stages of growth, expressed as per cent of total dry matter. The result indicates that after growth and podding have taken place no important changes occur, and harvesting may be governed by other conditions.

CONCLUSION AND SUMMARY.

1. The mung bean is developed quickly in a hot dry climate and can be raised in the semiarid sections of our country.

2. Its protein content is high, and, as indicated by chemical analysis the nitrogen distribution is fair.

3. Nutritional tests show that rats can grow to maturity with protein from this single source. Growth is somewhat below normal, and reproduction is limited.

4. Vitamin A is present in amounts greater than is to be found n many seeds.

5. A plentiful supply of vitamin B is present when the bean composes 60 per cent of the ration, and sodium, calcium, and chlorine seem to complete the mineral requirements.

6. A limited cooking seems to aid the nutritional value, while extensive cooking becomes detrimental.

7. The uneven ripening of the bean is detrimental but data obtained show that the entire plant may be harvested green any time after the pods are filled.

8. The indications are that the mung is a superior type of bean from a nutritional standpoint, but not adequate as a sole source of protein.

The writer wishes to acknowledge the assistance of Dr. N. B. Guerrant of this department, who made many of the chemical determinations, and Mr. Clay Potts and Mr. H. F. Murphy of the Agronomy Department who secured and classified the seed.

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