Mungbean as a Potential Iron Source in South Asian Diets

R.Y. Yang and S.C.S. Tsou
AVRDC
P.O. Box 42, Shanhua, Tainan 741 Taiwan

Introduction

The second report on the world nutrition situation indicated that the nutrition status of South Asia has improved significantly from 1975 to 1990. An increased trend over time has been observed in the dietary energy supply and percentage of underweight preschool children. However, over 50% of children in the region are underweight. Iron deficiency anemia is another common nutritional disorder in South Asia. Around 64% of women in their reproductive age stiffer from reduced working efficiency, diminished learning capacity, increased susceptibility to infections, and greater risk of death associated with pregnancy and childbirth due to deficiency of iron. Among other nutritional disorders, protein-caloric malnutrition and iron deficiency remain to be major concerns which deserve more attention.

A number of approaches can be taken to alleviate malnutrition. Among them, the dietary approach is more sustainable. However, it is more complex and involves a number of institutional and socioeconomic factors. Changes in dietary patterns are linked to agricultural practices which can provide incentives to farmers to enable them to supply the desired commodities at market prices acceptable to targeted populations. Furthermore, housewives may need to change ways of preparing food with the dishes they prepare still culturally acceptable to the family. Products are marketable when they can generate reasonable profit when processed. The selection of a commodity that can meet these conditions and still make significant contributions to nutrition will be the key factor in a successful nutrition program.

Mungbean is basically an Asian crop. It is one of the major caloric and protein sources in South Asia, especially for the vegetarian population. Many food items can be prepared from mungbean. The most popular food is dhal, which is consumed in almost every meal. Although mungbean primarily serves as a supplemental source of protein high consumption rate and improvement of its iron content and availability make it a significant contributor to the iron status in the South Asian diet.

Recent improvements in mungbean production technology demonstrated that mungbean cultivation can be further expanded in South Asia. With these technologies, producers will benefit from improved productivity and consumers will benefit from reduced unit price. It is projected that mungbean will become more popular even for the lower income population. Studies have been carried out to maximize its nutritional role as iron source in South Asia.

Nutritional quality of mungbean

Like most legumes, mungbean is rich in starch and protein. The compositions of mungbean and its processed products have been extensively recorded (Thirumaran and Seralathan 1988, Singh et al. 1988, Prabhavat 1988).

Mungbean starch consists of 65% dry matter. It is characterized by its high cross-linkage property (Lii et al. 1988). Mungbean starch noodle with its unique texture and good cooking quality is a special delicacy in Southeast Asia. The protein fraction, which is a by-product of the starch industry, has become a low-cost source for protein enrichment of other products in Southeast Asian countries (Singh 1988). Processed products from mungbean starch, however, are not popular in South Asia.

Mungbean protein is easily digestible. It has a chemical score of 32% limited by sulfur-containing amino acids. Rat-feeding experiments demonstrated that the protein efficiency ratio (PER) of a mixed diet of mungbean (25%) and rice (75%) could be enhanced from 1.7 to 2.6 through methionine and lysine enrichment (Tsou and Hsu 1978). Improvement of the protein quality of mungbean is desired to make it a more effective protein source to supplement cereal and rice.

Mungbean is rich in minerals but is a poor source of vitamins A and C. Most minerals, however, are low in bioavailability due to the presence of antinutritional factors. Improvements will be needed to make mtmgbean a better source of micronutrients. A combined agricultural and processing approach may help achieve this objective.

Improvement of nutritional quality of mungbean through sprouting

Mungbean is one of the most popular commodities for sprouting. Sprouting technologies were extensively studied and have made mungbean sprout a high-quality vegetable (Ahmad and Mohamed 1988, Chen et al. 1988, Ke et al. 1983). Sprout yield from 1 kg of mungbean seed varied from 4 to 8 kg depending on seed size and sprouting system used. Since mungbean sprout production can be done under controlled conditions and at home, sprouts can be served as a vegetable especially during off-season and/or in times of crisis.

Mungbean sprout is rich in vitamin C and minerals. The bioavailability of iron at various sprouting stages is shown in Fig. 1. A twelve-fold increment in iron bioavailability of sprout compared to mungbean can be observed. This is partially due to increased ascorbic acid and reduction of phytate during the sprouting period (AVRDC 1994).

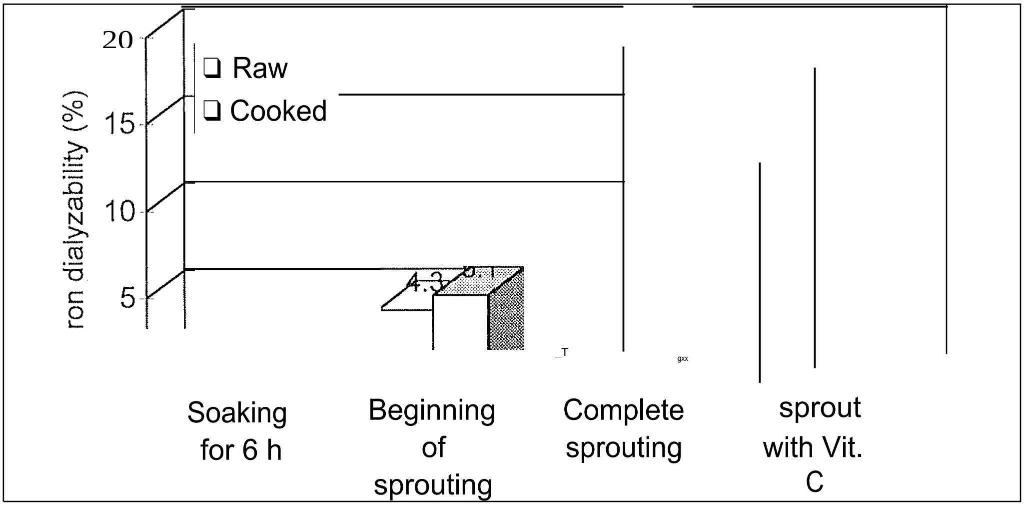

Fig. 1. Iron bioavailability of mungbean during sprouting .

It is estimated that one serving (100 g fresh weight) of mungbean sprouts can contribute 0.08 mg of available iron to our body which is equivalent to the iron content of cabbage and cauliflower. Mungbean sprout consumption provides an additional iron-rich vegetable to the diet, especially when there is a lack of other vegetables in the market. Technologies are available to make small amounts of sprouts for family use. Since the sprouting process is relatively simple and does not use sophisticated facilities, sprout can also be promoted as a potential vegetable for the school lunch program.

Variation of quality in mungbean germplasm

There are over 6000 mungbean germplasm accessions preserved at AVRDC. Quality of moisture, protein, and starch contents of these accessions were evaluated. Table 1 shows the composition ranges of the samples.

A set of mungbean materials, which were considered to have better adaptability in South Asia were evaluated for total iron, phytate, sprouting property, and partition of seed size. Iron bioavailability was also tested in some selected lines. The ranges observed for these properties are summarized in Tables 2 and 3.

Table 1. Characteristics of selected calibration curves for mungbean

Component	R` of calibration curve	Content range of calibration	Sample size	SEP of calibration test
Moisture	0.99	6.97-12.47	129	0.10
Protein	0.99	19.64-27.61	136	0.18
Starch	0.92	35.59-44.36	61	0.48

Table 2. Quality evaluation of nuulgbean seed

Sample name	Dry matter (%)	Protein (%)	Starch (%)	Iron content (mg/100 g)	Phy tic acid (%)	Bioavail-ability (Ya)
VC 6389(18-12)	89.8	25.4	55.9	6.42	0.9	5.0
VC 6371(20-7A)	89.3	26.1	54.1	6.22	0.8	3.4
VC 6370(21-3A)	89.0	26.2	54.6	6.23	0.9	2.3
VC 6370(21-16)	89.2	23.9	58.4	5.43	0.9	3.6
VC 6379(23-2-2)	89.5	24.5	55.6	6.29	0.9	1.9
VC 6379 (23-11)	89.3	23.5	58.4	5.63	0.9	1.9
VC 6379(23-11G)	89.4	23.6	56.2	5.70	0.9	2.0
VC 6375(41-13-6)	89.2	28.1	51.8	6.51	1.0	4.0
VC 6368(46-3)	89.3	26.2	54.1	6.12	0.8	2.9
VC 6368(46-13-2)	89.4	26.4	53.5	6.38	0.8	2.5
VC 6368(46-40)	89.3	23.6	55.4	5.79	0.8	2.9
VC 6386(34-7)	89.1	26.4	53.2	5.66	0.8	2.5
VC 3960-88	90.2	24.2	54.7	5.55	0.9	1.6
VC 6370-92	89.1	27.1	52.9	6.48	0.9	, 2.2
VC 6371-93	89.6	24.1	55.8	6.10	0.8	3.0
VC 6371-94	89.8	27.0	52.8	5.96	0.9	0.8
VC 6173B-14	88.5	25.0	55.6	5.91	0.9	2.5
VC 6159(1-1)	90.0	24.7	56.9	5.85	1.0	3.9
VC 6409-43	89.2	24.8	55.7	6.42	0.8	2.1
VC 6410-70	89.6	25.0	54.6	5.75	0.9	1.8

Table 3. Quality evaluation of mungbean sprout

Sample name	100-seed wt. (g)	Germin-ation (%)	Sprout prod. (g/100 g)	Iron content (mg/100 g)	Dry matter	Sprout length (cm)	Sprout width (cm)
VC 6389(18-12)	5.53	100	628	8.38	13.01	5.53	0.29
VC 6371(20-7A)	5.56	98	615	7.53	13.46	4.82	0.30
VC 6370(21-3A)	5.72	99	700	8.09	11.33	6.34	0.31
VC 6370(21-16)	5.71	97	606	7.19	13.04	7.05	0.28
VC 6379(23-2-2)	6.91	100	538	8.21	15.74	5.73	0.29
VC 6379(23-11)	5.44	100	528	8.22	16.33	5.06	0.27
VC 6379(23-11G)	5.88	100	580	7.65	14.24	5.68	0.28
VC 6375(41-13-6)	6.4	97	681	9.46	12.20	6.64	0.30
VC 6386(46-3)	5.47	79	573	8.25	14.85	5.11	0.29
VC 6368(46-13-2)	5.97	90	649	7.76	13.12	7.26	0.29
VC 6368(46-40)	5.65	85	641	8.16	11.91	6.01	0.28
VC 6386(34-7)	5.62	96	703	7.77	11.24	5.90	0.27
VC 3960-88	4.56	84	524	7.54	13.17	5.69	0.26
VC 6370-92	5.67	98	687	8.3	11.68	6.15	0.28
VC 6371-93	5.8	89	492	7.71	16.38	5.46	0.29
VC 6371-94	5.46	82	611	8.12	12.78	5.23	0.27
VC 6173B-14	7.02	88	526	8.07	15.26	5.40	0.31
VC 6159(1-1)	5.54	86	590	7.5	13.83	6.10	0.27
VC 6409-43	6.14	80	598	8.51	13.41	5.38	0.30
VC 6410-70	6.11	95	505	7.45	15.89	5.35	0.30

Germplasm evaluation experiments suggested that certain improvements in the nutritional quality of mungbean could be achieved through cross breeding. Potential improvement through genetic manipulation, however, does not promise a major change in nutritional quality of mungbean. Advanced tools, such as biotechnology will be needed for quality improvement. A transformation project, such as the introduction of a gene of protein with high s-containing amino acids in mungbean is ongoing.

Improving iron availability of mungbean through food preparation

Several studies are being carried out on the effects of processing on iron bioavailability Food processing provides an opportunity to add the most bioavailable iron salt to enhance nutritional quality of processed products. This approach is effective and involves industry and a possible sacrifice in product quality.

Another approach is at the household level during meal preparation. A number of scientific findings are applicable to enhance iron availability of mumgbean through food preparation.

Wet-heating often has an enhancing effect on iron availability. The presence of ascorbic acid can prevent the formation of less soluble ferric compound, thus, enhancing bioavailability Certain organic acids, such as citrate, may act as chelating agents and positively affect iron bioavailability.

Experiments were conducted to develop certain principles that can be applied to home preparation of mungbean and to recipe development. Fig. 2. shows the effect of adding ascorbic acid and citric acid to mungbean salting solutions before cooking. A sevenfold increase in dialyzable iron was observed when ascorbic acid treatment was combined with cooking. Treatment with citrate, however, showed no significant effect on iron bioavailability.

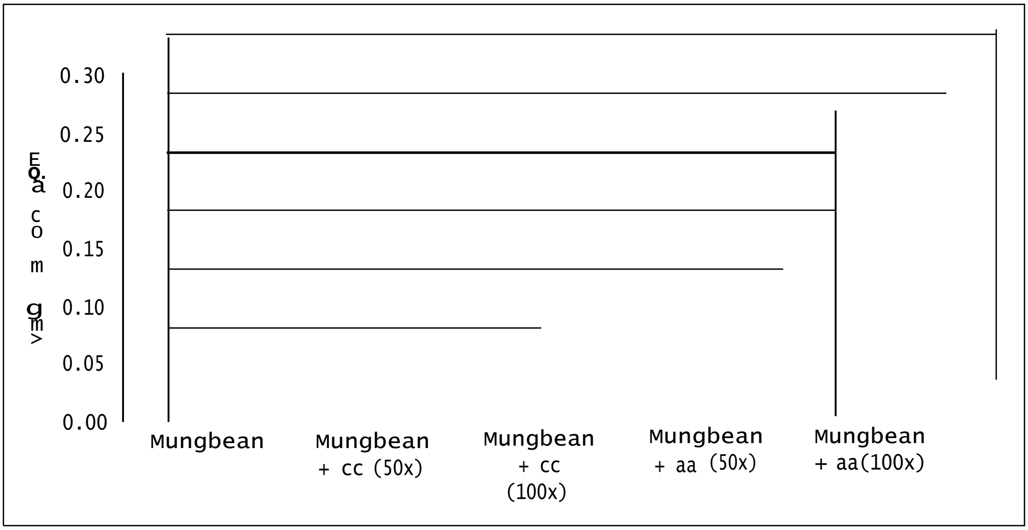

Fig. 2. Effect of ascorbic acid (aa) and citric acid (cc) on iron bioavailability of inungbean

It has been demonstrated that bioavailability in rice can be enhanced if it is boiled with tomato juice (AVRDC 1997). The effect of tomato on iron availability of mungbean was evaluated. A high iron bioavailability of 15% was observed when mungbean was cooked with tomato, with a mungbean to tomato ratio of 6'g/100 g.

Improving mungbean as a better iron source in South Asian diets

The nutritional contribution of a food item to a given nutrient can be expressed by the amount of intake of the product x nutrient density x bioavailability. Improvement in the contribution can be achieved through increases in any of these factors. Agricultural research is basically aimed at making a commodity physically and economically more accessible to the target population and thus, improving consumption rate. With modern varieties, one can expect that mungbean consumption rate will increase in South Asia. The primary impact of mungbean on nutritional status will be as a protein source. As the bioavailability of iron in mungbean is rather low, measures are needed to enhance iron absorption from mungbean.

Promoting sprout as part of the diet could be one possible approach. Sprout is a practical vegetable for the off-season when other vegetables are difficult to grow. As iron becomes more bioavailable in fully grown sprouts, which is not popular in South Asia, sprouting techniques need to be introduced and recipes developed for South Asian meals. It is unlikely that sprouts will be consumed everyday. Thus, it can be considered only as a supplemental source of iron.

Dhal is the most popular way of preparing mungbean in South Asia. It is consumed with rice in almost every meal. The weight ratio between rice and beans in most meals is around 9:1. As the iron content of mungbean is 3.3 times higher than rice, potentially mungbean can contribute more dietary iron than rice. It is estimated that improvement of iron availability of mungbean from 2.5 to 10% by enhancement through sprouting or cooking with vegetables, such as cabbage and tomato, will contribute 0.225 mg of available iron per day. This will meet about 10 and 20% of the 95th percentile of requirements per day (FAO/WHO 1988) for menstruating women and men, respectively.

Based on the booklet of mungbean recipes (AVRDC 1998) prepared by AVRDC recently, preparations such as mungbean dhal Koottu with vegetable, tomato rice with mungbean dhal, Pesarattu, and tomato Adai, which are commonly prepared in Indian households, are recommended for higher iron availability. It will be practical if nnmgbean consumption is increased to 60 g per day for one person, which is about 20 g more than the current estimated consumption. The available iron would then be up to 0.35 mg, which means mungbean iron contributes nearly 15 and 30% of basal requirement for women and men. The improvement of iron status in South Asia through increased mungbean consumption will be significant.

References

Ahmad, S.H. and Mohamed M.T.M. 1988. Effect of atmospheric carbon dioxide, oxygen, and ethylene on the growth and quality of mungbean sprouts. *In:* S. Shanmugasundaram (ed.). Second International Mungbean Symposium Proceedings. AVRDC, Shanhua, Tainan, Taiwan. p. 536-545.

AVRDC. 1994. Progress Report. AVRDC, Shanhua, Tainan, Taiwan. p. 239-243.

AVRDC. 1997. Quarterly Report to OMNI.

AVRDC. 1998. Mungbean recipes with focus on iron bioavailability (in press).

Chen, C.Y., S.C.S. Tsou, and H.H. Wang. 1988. Utilization patterns of mungbean in the Chinese diet. *In:* S. Shanmugasundaram (ed.). Second International Mungbean Symposium Proceedings. AVRDC, Shanhua, Tainan, Taiwan. p. 498-507.

FAO/WHO. 1988. WHO Report. Iron in "Requirements of vitamin A, iron, folate, and vitamin B12". p. 33-50.

Ke, L.S., D.C.N. Chang, and Y.B. Yu. 1983. Effects of endogenous ethylene and carbon dioxide production on the growth of 2,4-D-treated etiolated mungbean sprout. J. Agri. Asso. China, New Series 122:72-78.

Lii, C.Y., Y.L. Chu, and Y.H. Chang. 1988. Isolation and characterization of mungbean starch. *In:* S. Shanmugasundaram (ed.). Second International Mungbean Symposium Proceedings. AVRDC, Shanhua, Tainan, Taiwan. p. 528-535.

Prabhavat, S. 1988. Mungbean utilization in Thailand. *In:* S. Shanmugasundaram (ed.) Second International Mungbean Symposium Proceedings. AVRDC, Shanhua, Tainan, Taiwan. p. 508-519.

Singh, R.D. 1988. Trends and prospects for mungbean production in South and Southeast Asia. *In:* S. Shanmugasundaram (ed.). Second International Mungbean Symposium Proceedings. AVRDC, Shanhua, Tainan, Taiwan. p. 552-559.

Singh, V.P., A. Chhabra, and R.P.S. Kharb. 1988. Production and utilization of mungbean in India. In: S. Shanmugasundaram (ed.). Second International Mungbean Symposium Proceedings. AVRDC, Shanhua, Tainan, Taiwan. p. 486-497.

Thirumaran, A.S. and M.A. Seralathan. 1988. Utilization of mungbean. *In:* S. Shanmugasundaram (ed.). Second International Mungbean Symposium Proceedings. AVRDC, Shanhua, Tainan, Taiwan. p. 470-485.

Tsou, C.S. and M.S. Hsu. 1978. The potential role of mungbean as a diet component in Asia. *In:* R. Cowell (ed.). First International Mungbean Symposium Proceedings. AVRDC, Shanhua, Tainan, Taiwan. p. 40-45.