Food Chemistry **31** (1989) 139–148

Effect of Fenugreek Seeds (*Trigonella foenum graecum*) Supplementation on the Protein Quality of Rice (*Oryza sativum*), Wheat (*Triticum astivum*) and Jowar (*Sorghum vulgare*)

P. Udayasekhara Rao & R. D. Sharma

National Institute of Nutrition, Indian Council of Medical Research,
Jamai Osmania PO, Hyderabad—500007,
India

(Received 13 January 1988; revised version received and accepted
28 March 1988)

ABSTRACT

Defatted fenugreek seeds (DFF) when added at the 5% and 10% levels did not improve the protein quality of rice diets, but when added to wheat and jowar diets of rats, they increased the gain in body weight, food intake, PER and NPU values. Dry matter and protein digestibilities were slightly decreased. Lysine present in the fenugreek seems to play an important role in improving the quality of staples tested in this study.

INTRODUCTION

Diets supplemented with whole fenugreek seeds or defatted fenugreek flour (DFF) were found to reduce serum cholesterol levels both in experimental animals and man (Sharma, 1984; 1986; Valette *et al.*, 1984). This approach of lowering serum cholesterol entails consumption of fenugreek for long periods of time and with habitual diets. In our earlier experiment, the replacement of casein (up to 10%) by defatted fenugreek seeds (DFF) did not produce any deleterious effect on the protein quality of casein as assessed by protein efficiency ratio (PER), dry matter and protein digestibilities or net protein utilization (NPU), but further increasing of the level of fenugreek did

Food Chemistry 0308-8146/89/$03·50

reduce these parameters (Udayasekhara Rao & Sharma, 1987). Elmadfa & Kuhl (1976) tested the protein quality of cornflour alone and in a mixture with fenugreek seeds and observed a significant improvement in the quality of mixture protein. No other work has been reported in the literature on the effect of fenugreek supplementation on the quality of cereal protein. Rice, wheat and jowar are the major staples consumed by most Indians and these contribute nearly 70% of energy and protein intake. The proteins of these grains are deficient in lysine whereas that of fenugreek is rich in lysine. It was thought useful, therefore, to study the effect of supplementation of these staples with fenugreek seeds on their protein quality.

MATERIAL AND METHODS

Authentic varieties of wheat and rice were obtained from the Andhra Pradesh Agricultural University, Hyderabad, while jowar was obtained from the ICRISAT, Patancheru, Hyderabad. Fenugreek seeds were purchased from the local market. All grains were cleaned of extraneous matter and ground to pass through a 40 mesh sieve.

The fenugreek seed powder was extracted for 16 h in a Soxhlet apparatus with ether followed by alcohol for 24 h. The extracted fenugreek powder (DFF) was dried for 4 days at room temperature and used for the feeding experiment. The chemical composition of DFF has already been reported earlier (Udayasekhara Rao & Sharma, 1987). The protein contents of DFF, casein, rice, wheat and jowar, determined by the macro Kjeldahl technique were found to be 28·9, 75·0, 7·7, 12·4 and 9·7%, respectively.

Biological evaluation

Seventy eight, 23 day old, male albino rats of the Institute's colony were used for the study. They were randomly divided into 13 groups of 6 animals each. Group I was kept on a protein-free diet. The compositions of diets fed to rats are given in Table 1. Groups II, VI and X served as controls and received a cereal control diet which had the following composition (w/w); cereals (rice, wheat or jowar) 81–90; groundnut oil, 5; salt mixture, 4; vitamin mixture, 1 and the rest starch to make it 100 g. In the diets, III, IV, VII, VIII, XI, and XII a part of the diet was substituted at the 5% and 10% levels with fenugreek. The substitution was made at the expense of cereals (rice, wheat and jowar) so as to keep the protein levels at 7·1% for rice diets, 10·5% for wheat diets and 9·7% for jowar diets. Groups V, IX and XIII served as controls for the rice, wheat and jowar groups, respectively and received casein diet with

TABLE 1
% Composition of Experimental Diets

Ingredient of the diet	*Group*												
	I	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*	*XIII*
Vitamin mixture[a]	1	1	1	1	1	1	1	1	1	1	1	1	1
Salt mixture[b]	4	4	4	4	4	4	4	4	4	4	4	4	4
Groundnut oil	5	5	5	5	5	5	5	5	5	5	5	5	5
Casein	—	—	—	—	9·3	—	—	—	13	—	—	—	11·8
Rice	—	90	71	53	—	—	—	—	—	—	—	—	—
Wheat	—	—	—	—	—	81	69	57	—	—	—	—	—
Jowar	—	—	—	—	—	—	—	—	—	90	76	60	—
DFF	—	—	5	10	—	—	5	10	—	—	5	10	—
Starch	90	—	14	27	80·7	9	16	23	77	—	10	20	77·2

[a] Vitamin mixture according to Campbell (1963).
[b] Salt mixture according to USP XVII.

matching protein content. Diets were mixed with twice the amount of water and cooked by steaming for 10 min.

Rats were housed in individual cages and fed daily the respective diets. Animals were weighed once a week. Records of weight gain and total intake of food were kept for 28 days. Faeces were collected during the last four days of the experiment. Nitrogen content of the faeces was determined by the macro Kjeldahl technique. From these data, dry matter and protein digestibilities were calculated (Campbell, 1963). Animals were sacrificed at the end of the experiment and eviscerated carcasses were hydrolysed in 6N HCl. Their nitrogen content was determined and net protein utilization (NPU) was calculated (Miller, 1963). Methionine and lysine contents of each diet were also estimated using a microbiological assay technique (Barton-Wright, 1946).

The results were statistically analysed using an analysis of variance.

RESULTS AND DISCUSSION

Addition of fenugreek (DFF) to rice diet at the 5% level did not alter the protein quality of rice (Table 2). At the 10% level of substitution, however, food intake of animals was significantly decreased. This was probably due to the glutinous nature of fenugreek + rice mixture which animals found unpalatable. In this group, gain in body weight and PER were also significantly lower. The last would be expected from the low food intake. However, NPU was not affected at any level of substitution and was comparable to an isonitrogenous casein diet.

Incorporation of fenugreek (DFF) at the 5% and 10% levels in the wheat diet, resulted in small but graded increases of PER (with similar food intakes) and NPU values. However, these increases were statistically significant only at the 10% level. On the other hand, dry matter and protein digestibilities were not affected (Table 3).

Supplementation of jowar diets with DFF from 0—10% gave a significant and gradual increase in body weight gain, food intake, PER and NPU in rats (Table 4). On the other hand, there was a progressive decline in dry matter and protein digestibilities (significant for protein digestibility at the 10% level of substitution with DFF). The possible reason for this could be the high fibre components of DFF and jowar, being 50% and 14%, respectively.

The protein quality of cereals tested can be ranked as rice > wheat > jowar. The results of this study indicate that fenugreek when supplemented to a poor quality grain, like wheat and jowar, can increase their protein quality, but not rice. These results are in line with those reported earlier in

TABLE 2

Effect of Solvent Extracted Fenugreek Flour Supplementation on the Protein Quality of Rice

	Rice II	*Rice 5% DFF* III*	*Rice 10% DFF IV*	*Casein V*	*CD at 5%*
Food intake (g/4 weeks)	$318 \pm 8{\cdot}4^{a}$	$316 \pm 11{\cdot}5^{a}$	$246 \pm 8{\cdot}3^{b}$	$317 \pm 5{\cdot}4^{a}$	25·6
Gain in body weight (g/4 weeks)	$66 \pm 4{\cdot}8^{a}$	$64 \pm 5{\cdot}4^{a}$	$40 \pm 5{\cdot}2^{b}$	$71 \pm 2{\cdot}9^{a}$	13·8
PER	$2{\cdot}91 \pm 0{\cdot}151^{a}$	$2{\cdot}70 \pm 0{\cdot}143^{a}$	$2{\cdot}11 \pm 0{\cdot}237^{b}$	$3{\cdot}06 \pm 0{\cdot}89^{a}$	0·483
Adjusted PER	2·38	2·21	1·72	2·50	
Dry matter digestibility (%)	$89 \pm 1{\cdot}6^{a}$	$90 \pm 0{\cdot}8^{a}$	$89 \pm 1{\cdot}2^{a}$	$95 \pm 0{\cdot}3^{b}$	2·7
Protein digestibility (%)	$73 \pm 0{\cdot}9^{a}$	$72 \pm 1{\cdot}7^{a}$	$71 \pm 2{\cdot}7^{a}$	$86 \pm 0{\cdot}7^{b}$	4·9
NPU	$57 \pm 1{\cdot}4^{a}$	$60 \pm 3{\cdot}9^{ab}$	$65 \pm 3{\cdot}2^{b}$	$64 \pm 1{\cdot}6^{ab}$	7·9

* DFF, Defatted fenugreek flour.

Values given are Mean ± SE.

Values with the same superscript are not significantly different.

Protein in the diets ranged between 7·1 and 7·5%.

TABLE 3
Effect of Solvent Extracted Fenugreek Flour Supplementation on the Protein Quality of Wheat

	Wheat VI	*Wheat 5% DFF* VII*	*Wheat 10% DFF* VIII*	*Casein IX*	*CD at 5%*
Food intake (g/4 weeks)	$312 \pm 5{\cdot}5^{a}$	$316 \pm 9{\cdot}5^{a}$	$317 \pm 10{\cdot}1^{a}$	$336 \pm 6{\cdot}7^{a}$	24·1
Gain in body weight (g/4 weeks)	$70 \pm 2{\cdot}6^{a}$	$74 \pm 5{\cdot}0^{a}$	$78 \pm 3{\cdot}8^{a}$	$100 \pm 4{\cdot}1^{b}$	11·7
PER	$2{\cdot}04 \pm 0{\cdot}065^{a}$	$2{\cdot}22 \pm 0{\cdot}096^{ab}$	$2{\cdot}34 \pm 0{\cdot}056^{b}$	$3{\cdot}48 \pm 0{\cdot}099^{c}$	0·239
Adjusted PER	1·47	1·59	1·68	2·5	
Dry matter digestibility (%)	$89 \pm 0{\cdot}6^{ab}$	$87 \pm 1{\cdot}2^{ab}$	$86 \pm 1{\cdot}3^{a}$	$94 \pm 0{\cdot}4^{b}$	7·0
Protein digestibility (%)	$85 \pm 0{\cdot}7^{ac}$	$81 \pm 1{\cdot}8^{ab}$	$77 \pm 1{\cdot}5^{b}$	$87 \pm 0{\cdot}8^{c}$	4·9
NPU	$41 \pm 0{\cdot}8^{a}$	$46 \pm 1{\cdot}0^{b}$	$47 \pm 1{\cdot}7^{b}$	$66 \pm 2{\cdot}0^{c}$	4·4

* DFF = Defatted fenugreek flour.
Values given are Mean ± SE.
Values with the same superscript are not significantly different.
Protein in the diets varied between 10·5 and 10·9%.

TABLE 4

Effect of Solvent Extracted Fenugreek Flour Supplementation on the Protein Quality of Jowar

	Jowar X	*Jowar 5% DFF* XI*	*Jowar 10% DFF XII*	*Casein XIII*	*CD at 5%*
Food intake (g/4 weeks)	$218 \pm 7{\cdot}8^a$	$268 \pm 7{\cdot}7^b$	$302 \pm 6{\cdot}5^c$	$323 \pm 4{\cdot}4^d$	20·2
Gain in body (g/4 weeks)	$22 \pm 1{\cdot}5^a$	$44 \pm 2{\cdot}1^b$	$63 \pm 2{\cdot}7^c$	$99 \pm 2{\cdot}0^d$	6·2
PER	$1{\cdot}09 \pm 0{\cdot}052^a$	$1{\cdot}78 \pm 0{\cdot}046^b$	$2{\cdot}18 \pm 0{\cdot}067^c$	$3{\cdot}36 \pm 0{\cdot}027^d$	0·152
Adjusted PER	0·81	1·32	1·62	2·5	
Dry matter digestibility (%)	$89 \pm 1{\cdot}6^a$	$88 \pm 0{\cdot}5^{ab}$	$86 \pm 0{\cdot}4^b$	$93 \pm 1{\cdot}0^c$	2·2
Protein digestibility (%)	$81 \pm 1{\cdot}1^a$	$77 \pm 0{\cdot}8^b$	$74 \pm 1{\cdot}1^c$	$86 \pm 1{\cdot}0^d$	3·0
NPU	$30 \pm 0{\cdot}6^a$	$36 \pm 1{\cdot}1^b$	$44 \pm 2{\cdot}4^c$	$66 \pm 1{\cdot}2^d$	4·5

* DFF = Defatted fenugreek flour.

Values given are Mean ± SE.

Values with the same superscript are not significantly different.

Protein in the diets ranged between 9·1 and 5%.

TABLE 5
Amino Acid Content, PER and NPU of Experimental Diets

Diet	*Protein content of diet (%)*	*Lysine* (*g/100 g diet*)	*Methionine* (*g/100 g diet*)	*PER*	*NPU*
Casein	7·3	0·439	0·094	3·06	64
Rice	7·1	0·324	0·130	2·91	57
Rice + 5% DFF[a]	7·4	0·338	0·114	2·70	60
Rice + 10% DFF	7·5	0·351	0·097	2·11	65
Casein	10·6	0·641	0·137	3·48	66
Wheat	10·8	0·231	0·139	2·04	41
Wheat + 5% DFF	10·6	0·283	0·131	2·22	46
Wheat + 10% DFF	10·5	0·329	0·121	2·34	47
Jowar	9·2	0·177	0·167	1·09	30
Jowar + 5% DFF	9·3	0·229	0·151	1·78	36
Jowar + 10% DFF	9·5	0·279	0·135	2·18	44

[a] DFF = Defatted fenugreek flour.

that proteins in legumes such as Bengal gram (chick peas), black gram, green gram and red gram (pigeon pea) supplement wheat proteins, jowar proteins and bajra proteins but not rice proteins (Phansalkar *et al.*, 1957; Yadav & Liener, 1977). It is now well recognized that the relative lack of one or more of the essential amino acids reduces the biological value of food proteins (Flodin, 1957). Similarly, correction of this deficiency by a combination of foods whose amino acid content is adequate, or by addition of the missing amino acid in the synthetic form, has been found to result in improved biological value (Scrimshaw *et al.*, 1958). For example, addition of lysine or lysine-rich foods showed an improvement in the quality of cereal protein (Sure, 1955; Howe *et al.*, 1965).

In the present study, as shown in Table 5, addition of fenugreek to cereals resulted in an increase of lysine content and a decrease of methionine content

TABLE 6
Correlation Coefficients between Lysine and Methionine Content of Diets versus PER and NPU

	PER	*NPU*
Lysine	0·871**	0·812*
Methionine	−0·545	−0·801*

* $P < 0{\cdot}01$; ** $P < 0{\cdot}001$.

of cereal diets. The PER and NPU values also showed an improvement. The lysine content of diets showed a positive correlation with PER and NPU values while methionine content exhibited a negative correlation with NPU values (Table 6). Supplementation of fenugreek to rice diet resulted in a small increase in the lysine levels but methionine levels were decreased. The fall in PER is almost certainly due to the fall in food eaten by animals. In the other two cereals (wheat and jowar) lysine levels were increased and methionine levels were decreased on addition of fenugreek.

These data suggest that fenugreek supplements the protein quality of commonly used cereals and probably the lysine content of DFF plays an important role in elevating the nutritive value of cereal proteins.

ACKNOWLEDGEMENTS

The authors thank Dr B. S. Narasinga Rao, Director, National Institute of Nutrition, for his interest in the work, and Mr P. Ramulu and Mr V. Vikas Rao for their technical assistance.

REFERENCES

Barton-Wright, E. C. (1946). The microbiological assay of amino acids. The assay of tryptophan, leucine, isoleucine, valine, cystine, methionine, lysine, phenylalanine, histidine, arginine and threonine. *Analyst*, **II**, 267.

Campbell, J. A. (1963). In *Evaluation of Protein Quality* National Academy of Sciences—National Research Council Publication, Washington DC, 1100, 31.

Elmadfa, A. & Kuhl, B. E. (1976). Quality of fenugreek seed protein tested alone and in a mixture with cornflour. *Nutr. Rep. Int.*, **14**, 165.

Flodin, N. W. (1957). Amino acid balance and efficiency of protein utilization. *Metabolism*, **6**, 350.

Howe, E. E., Jansen, G. R. & Gilfillan, E. W. (1965). Amino acid supplementation of cereal grain as related to world food supply. *Am. J. Clin. Nutr.*, **16**, 315.

Miller, D. S. (1963). In *Evaluation of Protein Quality*. NAS-NRC Publication, Washington DC, 1100, p. 34.

Phansalkar, S. V., Ramchandran, M. & Patwardhan, V. N. (1957). *Ind. J. Med. Res.*, **45**, 611.

Scrimshaw, N. S., Bressani, R., Behar, M. & Vitari, F. (1958). Supplementation of cereal proteins with amino acids. *J.* Nutr., **66**, 485.

Sharma, R. D. (1984). Hypocholesterolemic activity of fenugreek (*T. foenum graecum*). An experimental study in rats. *Nutr. Rep. Int.*, **30**, 22.

Sharma, R. D. (1986). An evaluation of hypocholesterolemic factor of fenugreek seeds (*T. foenum graecum*) in rats. *Nutr. Rep. Int.*, **33**, 669.

Sure, B. (1955). Effect of amino acid and vitamin supplements on the biological value of proteins in rice and wheat. *J. Am. Dietet. Assoc.*, **31**, 1232.

Udayasekhara Rao, P. & Sharma, R. D. (1987). An evaluation of protein quality of fenugreek seeds (*T. foenum graecum*) and their supplementary effects. *Food Chem.*, **24**, 1.

Valette, G., Sauvaire, Y., Baccou, J. C. & Ribes, G. (1984). Hypocholesterolemic effect of fenugreek seeds in dogs. *Atherosclerosis*, **50**, 105.

Yadav, N. R. & Liener, I. E. (1977). Optimizing the nutritive value of the protein of navy beans (*Phaseolus vulgaris*) by complementation with cereal protein. *Legume Res.*, **1**, 17.