Indian Journal of Animal Sciences **72** (8): 643-647, August 2002

Composition of faba bean (*Vicia faba* L.): Nutritional response upon processed beans feeding in rats

AMEETA KUSHWAH[1], H S KUSHWAH[2], PRAKRATI RAJAWAT[3] and SEEMA SHROTI[4]

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh 482 001 India

Received: 5 March 2001; Accepted: 12 January 2002

ABSTRACT

Among 7 varieties of faba bean (*Vicia faba* L.), JV-2 contained maximal protein and minimal anti-trypsin activity and exhibited highest *in vitro* protein digestibility. However, the level of S-containing amino acid was low. Heat treatments and germination of the beans affected their composition variably. Feeding experiment in rats on isoproteinic (10%) raw and processed bean diets recorded significantly higher growth rate and protein efficiency ratio on processed beans particularly upon germination compared to raw bean. Digestibility coefficient, biological value and net protein utilization were also maximally depicted by germinated bean fed animals followed by heat treated compared to raw bean fed group.

Key words: Feeding, Nutritional response, Rats, *Vicia faba*

The presence of certain anti-nutritional factors (Rajawat *et al.* 1999) and the imbalance in sulphur amino acids (Adsule and Akpapunam 1996) induce certain undesirable biochemical and physiological effects (Rubio *et al.* 1990, Martinez *et al.* 1992). However, processing of beans upon heat treatment (Rani and Hira 1993, Rajawat *et al.* 1999) or germination (Rani and Hira 1993) may alleviate the content of trypsin inhibitor, polyphenols and lectins partially or completely thereby, improving the quality of the beans. This study was designed to investigate into the relative nutritional utilization of faba bean, raw or processed, by the biological system.

MATERIALS AND METHODS

Seven varieties of faba bean (*Vicia faba* L.)—JV-2, VH-123, VH-133, VH-82-21, DHB-85-3, JV-1 and DBH-2, procured from the University were washed with distilled water to remove all extraneous materials, oven dried at 50°C and powdered (60μ mesh sieve). These were analyzed separately for proximate composition, mineral contents as detailed earlier (Diwakar *et al.* 1996a), methionine and tryptophan concentration (Rajawat *et al.* 2000), and for the presence of trypsin inhibitor activity, polyphenols, haemagglutinin titres and their *in vitro* protein digestibility (Rajawat *et al.* 1999).

Based on maximal protein content and minimal anti-trypsin activity, seeds of JV-2 were selected and subjected to roasting, autoclaving and germination (Diwakar *et al.* 1996 b). Germinated and autoclaved seeds were oven-dried at 50°C for 24 hr. The processed seeds were powdered and passed through a 60μ mesh sieve and analyzed for their proximate composition (AOAC 1990) and presence of anti-nutritional metabolites (Rajawat *et al.* 1999).

Isoproteinic diets (4) were prepared using differently processed faba beans, setting protein at 10% level (Table 5) and compared with casein, a biologically active protein source, by feeding to 30 rats (6 in each group) for 28 days. All the diets were subjected to steaming for 5 min separately prior to feeding to the rats. Diet consumption was monitored daily. The rats were weighed at the start and end of the feeding trial and protein efficiency ratio (PER) was calculated (AOAC 1990). Thereafter, rats were housed in individual metabolic cages and fed on 10% isoproteinic diets separately as indicated above for 3 days. On each day, urine samples were collected over 0.5 ml of toluene and 1 ml of HCl (0.1N). Faecal samples were also collected in separate containers. Nitrogen content of urine and faecal samples was determined by Microkjeldhal (N × 6.25) (AOAC 1990). The net protein utilization (NPU), digestibility co-efficient (DC) and biological value (BV) were calculated by standard formulae (AOAC 1990).

The data were subjected to analysis of variance (Snedecor and Cochran 1994).

RESULTS AND DISCUSSION

Among all the varieties tested, JV-2 exhibited the maxi-

Present address: [1]University Professor, [2]University Professor and Head, [3,4]Research Fellow, Department of Animal Biochemistry and Biotechnology, College of Veterinary Science and Animal Husbandry.

Table 1. Proxmate principles and limiting amino acids in different varieties of faba bean (*Vicia faba* L.) on dry matter basis

Variety	Proximate principles (g%)						Limiting amino acids (g%)	
	Moisture	Crude protein	Ether extract	Carbohydrate	Crude fibre	Ash	Tryptophan	Methionine
JV-1	9.50[a]	20.16[a]	1.73[a]	49.41[a]	7.51[a]	2.50[a]	0.232[a]	1.07[a]
	±0.060	±0.542	±0.011	±0.502	±0.206	±0.015	±0.003	±0.039
JV-2	10.20[a]	22.09[a]	1.88[b]	46.13	9.56[a]	3.05[a]	0.148[b]	0.91[a]
	±0.176	±0.262	±0.065	±0.206	±0.135	±0.071	±0.002	±0.094
VH-82-21	9.04[a]	14.82[b]	1.65[a]	51.11[a]	11.55	3.45[b]	0.141[b]	0.61[b]
	±0.075	±0.199	±0.006	±0.164	±0.172	±0.033	±0.008	±0.039
VH-123	10.10[a]	18.69[a]	1.97[b]	47.72[b]	9.26[a]	2.98[a]	0.122[c]	0.46[c]
	±0.204	±0.106	±0.063	±0.385	±0.040	±0.048	±0.008	±0.039
VH-133	9.10[a]	18.54[a]	1.20[a]	50.54[a]	8.81[a]	3.30[a]	0.077[c]	0.73[b]
	±0.175	±0.766	±0.00	±0.855	±0.018	±0.012	±0.003	±0.011
DHB-2	7.01[b]	21.01[a]	1.32[a]	51.51[a]	9.30[a]	3.13[a]	0.243[a]	1.07[a]
	±0.164	±0.274	±0.011	±0.403	±0.00	±0.017	±0.003	±0.039
DHB-85-3	9.30[a]	18.41[a]	1.56[a]	50.15[a]	8.75[a]	3.22[a]	0.122[c]	0.61[b]
	±0.063	±0.589	±0.005	±0.515	±0.032	±0.032	±0.007	±0.039

Values are mean ±SE of 6 observations; values with different superscripts in a column are significantly different P<0.05.

mum concentration of crude protein (P<0.05), the concentration of fat, ash and crude fibre was also high (Table 1). Relative concentration of calcium, potassium, sodium, phosphorus, zinc and manganese was also satisfactorily high (Table 2). However, the content of tryptophan and methionine was low (Table 1). Variation among varieties may be attributed to specific and varietal differences; genetic factors may also be significant (Sammour 1987).

Variety JV-2 contained minimal antitrypsin activity, the maximum being in VH-82-21 (P<0.05) (Table 3). Its level in varieties VH-123 and DBH 85-3 was also low. Free and bound polyphenols were highest in VH-133 and JV-2, respectively, minimal being in VH-123 and DBH-2, respectively, (vs. each other, P<0.05) (Table 3). Environmental and genetic factors are reported to cause variations among varieties (Gorski *et al.* 1985). Diwakar *et al.* (2001) reported variation in haemagglutinin among different varieties. *In-vitro* protein digestibility ranged from 59 to 65% and was highest in JV-2.

Among all the varieties, JV-2 was selected for its maximal protein content and minimal anti-trypsin activity for further processing. Germination of the beans improved their protein content significantly (P<0.05) (Table 4).

Animals fed on either raw or processed JV-2 variety of faba bean (*Vicia faba* L.) exhibited a higher feed intake and

Table 2. Concentration of mineral elements in different varieties of faba bean (*Vicia faba* L.)

Elements	JV-1	JV-2	VH-82-21	VH-123	VH-133	DBH-2	DBH-85-3
Micro elements (μg/g)							
Zinc	31.60[a]	30.54[b]	33.20[c]	20.13[d]	33.65[c]	36.30[a]	33.56[c]
	±0.410	±1.010	±0.000	±0.321	±0.370	±0.000	±0.162
Copper	37.14[a]	9.80[b]	32.77[c]	8.28[b]	34.11[c]	35.83[c]	34.02[c]
	±0.490	±0.201	±0.230	±0.116	±0.403	±0.360	±0.000
Manganese	4.52	4.49	4.55	4.50	4.54	4.65	4.53
	±0.000	±0.000	±0.000	±0.000	±0.000	±0.000	±0.000
Macro elements (%)							
Calcium	0.27[a]	0.56[b]	0.42	0.60[b]	0.81[d]	0.43[c]	0.50[b]
	±0.005	±0.015	±0.005	±0.004	±0.005	±0.005	±0.003
Potassium	0.84[a]	0.71[b]	0.84[a]	0.74[b]	0.75[b]	0.82[ab]	0.72[b]
	±0.004	±0.016	±0.007	±0.006	±0.000	±0.006	±0.004
Sodium	0.25[a]	0.25[a]	0.12[b]	0.26[a]	0.21[c]	0.16[d]	0.21[c]
	±0.001	±0.001	±0.001	±0.005	±0.001	±0.001	±0.000
Phosphorus	0.52[a]	0.52[a]	0.44[b]	0.50[a]	0.43[b]	0.54[a]	0.45[b]
	±0.001	±0.001	±0.001	±0.001	±0.002	±0.000	±0.001

Values are mean±SE of 6 observation; values with different superscripts in a row are significantly different (P<0.05).

Table 3. Anti-nutritional factors and *in-vitro* protein digesibility in different varieties of faba bean (*Vicia faba* L.)

Varieties	Trypsin inhibitor (%)	Free polyphenols (mg/g)	Bound polyphenols (mg/g)	Haemagglutinin*	*In vitro* protein digestibility (%)
JV-1	44.90[a]	10.83[a]	7.70[a]	1: 16	64.94[a]
	±3.604	±0.084	±0.246		±0.843
JV-2	17.20[b]	11.16[b]	9.65[b]	1: 16	65.90[a]
	±1.403	±0.293	±0.206		±0.631
VH-82-21	62.02[c]	9.40[c]	7.50[a]	1: 16	62.50[b]
	±2.531	±0.405	±0.054		±0.223
VH-123	22.11[d]	7.18[d]	6.31[c]	1: 16	61.61[b]
	±0.610	±0.343	±0.563		±0.760
VH-133	47.70[e]	10.05[e]	0.08[d]	1: 32	63.03[ab]
	±3.490	±1.250	±0.436		±1.311
DBH-2	47.04[e]	7.23[d]	6.22[c]	1: 128	64.04[a]
	±2.931	±0.372	±0.208		±0.447
DBH-85-3	28.01[f]	9.19[c]	7.81[a]	1: 8	59.01[c]
	±1.190	±0.223	±0.150		±0.447

Values are mean±SE of 6 observations; values with different superscripts in a column are significantly different (P<0.05); *As per Diwakar *et al.* (2001).

thus, reflected higher protein intake values compared to control casein fed animals. The rate of growth and PER in raw bean fed rats were significantly lower than control group (Table 6). Feeding of animals on processed bean diet namely, autoclaved, roasted or germinated, improved their rate of growth over raw bean fed animals; the increase being maximal in germinated group followed by roasted and autoclaved groups.

The findings reflected the outstanding growth inhibiting deficiency (Table 1) may be attributed to these effects.

The rate of growth in rats fed on processed faba beans was comparable to those fed on casein diet (Table 6). In addition, PER values were also remarkably improved but still were significantly lower than control animals (Table 6). This suggested processed faba bean to be nutritionally superior to raw beans as reported earlier (Rani and Hira 1993, Kushwah *et al.* 2002). The results further reflected that though the feed/protein intake values in heat treated faba bean group did not

Table 4. Effect of processing on chemical compsition of JV-2 faba bean (*Vicia faba* L.)

Varieties	Moisture (%)	Crude protein (%)	Ether extract (%)	Carbohydrate (%)	Crude fibre (%)	Ash (%)
Roasted	6.71[a]	21.40[a]	1.90[a]	57.79[a]	64.94[a]	2.99[a]
	±0.022	±0.001	±0.102	±0.201	±0.035	±0.010
Autoclaved	7.32[b]	23.00[b]	1.01[b]	56.77[a]	9.01[a]	2.89[a]
	±0.037	±0.021	±0.002	±0.120	±0.041	±0.201
Germinated	7.90[b]	25.63[c]	1.87[a]	52.10[b]	9.49[a]	3.01[a]
	±0.076	±0.100	±0.017	±0.142	±0.113	±0.071

Values are mean±SE of 6 observations; values with different superscripts in a column are significantly different (P<0.05).

effect on growing animals when fed on raw faba bean alone and are well correlated with earlier reported data (Rubio *et al.* 1990, Martinex *et al* 1992). However, this growth inhibition is accompanied by high food/protein intake and therefore suggested poor dietary protein utilization by raw bean fed animals. Several undesirable biochemical and physiological effects, usually accompanied by impairment of growth, are observed in growing animals when raw legumes account for the sole or major source of proteins in their diets (Gupta 1987, Larralde and Martinez 1989). Low digestibility of such proteins (Macarulla *et al.* 1989) or the sulphur amino acid differ much from raw fed group, yet the corresponding rate of growth was remarkably much higher (Table 6) thereby, inferring to better utilization of processed beans by rats. Earlier workers too, demonstrated an improvement in the nutritional value of faba bean upon heat treatment (Rani and Hira 1993), and it is being associated with the destruction of antinutritional factors (Kushwah *et al.* 2001) and an improvement in the availability or digestibility of several nutrients including carbohydrates and proteins (Marquardt and Ward 1979).

A study on digestibility coefficient (DC), biological value

Table 5. Composition of the diets for the experimental period of 28 days in weaning rats

Constituent g/ 100g of diet	Casein	Raw	Roasted	Autoclaved	Germinated	Non protein
Protein	12.5	45.45	46.79	43.47	39.01	-
Fat (ml/100g of diet)	8	7.11	7.11	7.56	7.27	8
Vitamin+mineral mixture	2	2	2	2	2	2
Starch	72	45.44	46.20	46.97	51.72	89
Crude fibre	1	-	-	-	-	1
Total	100	100	100	100	100	100

Values are mean±SE of 6 observations; values with different superscripts in a column are significantly different (P<0.05).

Table 6. Nutritional evaluation of raw and processed faba bean (*Vicia faba* L.) feeding in rats

Varieties	Casein	Raw	Autoclaved	Roasted	Germinated
Feed intake (g)	163.80[a]	274.20[a]	256.40[a]	255.10[a]	274.60[a]
	±44.50	±10.68	±8.86	±23.46	±50.84
Protein intake (g)	16.38[a]	27.42[a]	25.65[a]	25.51[a]	27.46[a]
	±4.45	±1.19	±0.88	±2.35	±5.08
Weight gain (g)	40.57[a]	18.00[b]	28.59[a]	37.50[a]	47.00[a]
	±11.94	±4.66	±4.60	±3.35	±11.28
Protein efficiency ratio	2.47[a]	0.66[b]	1.11[c]	1.47[c]	1.71[c]
	±0.33	±0.17	±0.13	±0.18	±0.17
Biological value (%)	66.96[a]	52.00[b]	47.00[b]	37.00[d]	66.00[a]
	±2.76	±3.35	±4.45	±5.07	±3.37
Digestibility coefficient (%)	32.00[b]	57.00[c]	66.00[c]	81.00[a]	
	±1.26	±3.58	±3.02	±6.00	±5.09
Net protein utilization (%)	16.64[b]	26.79[b]	24.42[b]	53.46[a]	
	±1.68	±1.93	±0.1.65	±2.91	±4.41

Values are mean±SE of 6 observations; values with different superscripts in a column are significantly different (P<0.05).

(BV) and net protein utilization (NPU) demonstrated that these values were the highest in the germinated bean fed animals and were *at par* to casein fed animals (Table 6). Rats fed on raw faba bean exhibited a marked reduction in these values that corroborated well with the reports of Sobrini *et al.* (1982). It reflected that rats fed on diets containing raw faba bean as the only source of protein suffered a pronounced anti-nutritive effect; processing of the beans especially germination, improved their nutritive effects (Table 5) as reported earlier (Kushwah *et al.* 2001).

The anti-nutritive effect of raw faba bean seeds is well established (Liener 1980) and is associated with the presence of anti-nutritional metabolites naturally present in them (Rani and Hira 1993, Rajawat *et al.* 1999). Processing of the beans improved the ability of the rats to absorb, retain and utilize the nitrogen in the diets especially upon feeding on germinated bean diet. Autoclaving and heat treatments also improved these values (Table 6). Destruction of anti-nutritional components during heat treatments (Kushwah *et al.* 2001) may result in a significant improvement in the utilization of most nutrients particularly, the amino acids (Marquardt *et al.* 1977). An increased ability of the intestinal tissues to transport amino acids being readily available, due to an increased solubility of proteins during germination of the seeds (Rahma 1988) may also be relevant. Germinated faba bean seeds is therefore the most recommendable form in the diet.

REFERENCES

Adsule R N and Akpapunam M. 1996. Faba bean (*Vicia faba* L.) *Food and Feed from Legumes and Oilseeds* pp. 197 Eds. Nwokola, E. and Smartt, J. Chapman and Hall, London.

AOAC. 1990. *Official Methods of Analysis.* Association of Official Analytical Chemists. Washington, DC-20044 USA.

Diwakar P, Kushwah A and Kushwah H S. 1996 a. Biochemical Composition of horse gram (*Dolichos biflorus* L.) in Madhya Pradesh. *The Indian Journal of Nutrition and Dietetics* **33**: 188-52.

Diwakar P, Kushwah A and Kushwah H S. 1996 b. Effect of processing on the functional properties of some local varieties of horse gram (*Dolichos biflorus* L.) in Madhya Pradesh, *Journal of Food Science and Technology* **33** 150.

Diwakar P, Kushwah A, Kushwah H S, Rajawat P and Shroti S. 2001. Relative haemagglutinin titres of faba bean (*Vicia faba* L.) and horse gram (*Dolicos biflorus L.*) against human and animal blood. *Indian Journal of Animal Sciences.* Accepted.

Gorski P M, Kasparzyk M and Brzozowski J. 1985. Variation in

tannin content of faba bean (*Vicia faba* L.) seed coats. *Faba Bean Information Services* **11**: 26-28.

Gupta Y P. 1987. Anti-nutritional and toxic factors in food legumes: A review. *Plant Food for Human Nutrition* **37**: 201-28.

Kushwah A, Kushwah H S and Rajawat P. 2001. Effect of domestic processing on anti-nutritional components and in-vitro protein digestibility of faba bean (*Vicia faba* L.). *Indian Veterinary Medical Journal* **25**: 179-80.

Kushwah A, Rajawat P and Kushwah H S. 2002. Nutritional evaluation of extruded faba bean (*Vicia faba* L.) as a protein supplement in cereals based diet in rats. *Indian Journal of Experimental Biology* **40**: 49-52.

Larralde L and Matinez J A. 1989. A reappraisal of the nutritional utilization of legumes. *Rovista espanola n Fisiologia* **45**: 220.

Liener I E. 1980. *Toxix Constituents of Plant Food Stuffs*. (Ed.), Liener I E. Academic Press, New York, USA.

Macarulla M T, Martinez J A, Barcina Y and Larralde J. 1989. Intestinal absorption of D-galactose in the presence of extracts from Phaseolus Vulgaris hulls. *Plant Food for Nutrition* **39**: 359-68.

Mar quardt R R and Ward A T. 1979. Chick performance as affected by autoclave treatment of tannin containing and tannin free cultivars of faba beans. *Canadian Journal of Animal Science* **59**: 781-89.

Marquardt R R, Ward A T, Campbell L D and Cansfield P E. 1977. Purification, identification and characterization of growth inhibitor in faba beans. *Journal of Nutrition* **107**:1313-24.

Martinez J A, Macarulla M T, Marcos R and Larralde J. 1992. Nutritional outcome and immunocompatence in mice fed on a diet containing raw field bean (*Vicia faba* Var minor) as the source of protein. *British Journal of Nutrition* **68**: 493-03.

Rahma E H. 1988. Functional and electrophoretic characteristics of faba bean (*Vicia faba* L.) flour proteins as affected by germination. *Die Nehrung* **32**: 577.

Rajawat P, Kushwah A and Kushwah H S. 1999. Effect of extrusion cooking variables on anti-nutritional components and *in-vitro* protein digestibility of faba bean. *Indian Journal of Animal Nutrition* **16**: 301-05.

Rajawat P, Kushwah A and Kushwah H S. 2000. Effect of extrusion cooking variables on biochemical composition of faba bean (*Vicia faba* L.). *Journal of Food Science and Technology* **37**: 373-79.

Rani N and Hira C K. 1993. Effect of various treatments on nutritional quality of faba bean (*Vicia faba* L.). *Journal of Food Science and Technology* **30**: 413-16.

Rubio L A, Brennes A and Castano M. 1990. The utilization of raw and autoclaved faba beans and faba bean fractions. *British Journal of Nutrition* **63**: 419-30.

Sammour R H. 1987. Chemical constituents and electrophoresis of seed proteins of some species of Vicia. *Faba Bean Information Services* **18**: 30-32.

Snedecor G W and Cochran W G. 1994. *Statistical Methods*. Indian 8th edn. The Iowa State University Press, USA.

Sobrini F J, Santidrian S and Larralde J. 1982. Nutritive value and effect of tannin content on *Vicia faba* L. equina and minor seeds on the rate of growth of growing rats. *Faba Bean Information Services* **5**: 32-35.