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Nutrient composition and antinutritional factors of rice bean (*Vigna umbellata*)

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The nutrient profile and levels of antinutritional factors of five high yielding varieties of rice bean (*Vigna umbellata*) and one variety each of green gram and black gram were investigated. The proximate compositions of rice bean varieties did not vary significantly among themselves and were comparable with those of green gram and black gram, except for protein content, which was significantly lower in rice bean. However, the concentrations of riboflavin and ascorbic acid varied significantly among the rice bean varieties and were comparable with those of green gram and black gram. Amounts of unsaturated fatty acids were higher than saturated. There were some significant differences among the rice bean varieties in their total and extractable mineral contents, which were comparable with those of green gram and black gram, except for calcium, which was twice as great in rice bean than in black gram and green gram. The trypsin inhibitor activity and contents of phytic acid, polyphenolic compounds and saponins varied significantly.

INTRODUCTION

Grain legumes are the major sources of dietary proteins in all the developing countries because animal proteins are expensive. Unfortunately, per capita availability of pulses is declining in most of the countries, resulting in protein malnutrition in vulnerable sections of society. We need high yielding varieties and new technology that will increase the production and nutritive value of grain- and oil-seed legumes to alleviate the protein deficiency. Currently, in addition to the programmes for development of high-yielding varieties of legumes through hybridization, greater attention is being paid to the exploitation of nonconventional legumes like jack bean, rice bean, etc.

Rice bean (*Vigna umbellata*), a native of south and south-east Asia, is now also grown in Fiji, Mauritius, Queensland and East Africa for fodder, green manure, cover crop and food (Thomas *et al.*, 1983). It has rich genetic diversity, high agricultural and nutritive potential, in terms of its being able to grow well in comparatively poor soils in hot and humid climates, and resistance to storage pests and serious diseases (Chandel *et al.*, 1978; Mukherjee *et al.*, 1980). However, the information on nutrient composition and antinutritional factors of rice bean now being introduced by plant breeders for human consumption is scanty. Therefore, this study was undertaken to investigate the nutrient composition as well as the content of various antinutritional factors present in different varieties of rice bean and to compare their nutritive value with other traditional legumes.

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MATERIALS AND METHODS

Materials

The seeds of five high yielding varieties (RB-4, RB-32, RB-37, RB-40 and RB-53) of rice bean (*V. umbellata*) and one variety each of green gram (K-851) and black gram (MT-9) were obtained from the Department of Plant Breeding, Haryana Agricultural University, Hisar. Green gram and black gram have been included in the present study as controls to compare the nutritional composition of these traditional legumes with that of rice bean. The seeds, after thorough cleaning and freeing from broken seeds, dust and other foreign materials, were ground to a fine powder (60 mesh) and stored in airtight plastic containers for chemical analysis.

Proximate composition

Samples were analysed for moisture, total nitrogen, fat, ash and crude fibre by employing standard methods (AOAC, 1980). A factor of 6·25 was applied to convert N to crude protein. Riboflavin and ascorbic acid were determined photofluorometrically and titrimetrically, respectively (AOAC, 1980).

Carbohydrates

The total water-soluble sugars were extracted according to the procedure of Cerning & Guilbot (1973) and estimated by the method of Yemn & Willis (1954). Reducing sugars were determined by the modified method of Somogyi (1945), whereas nonreducing sugars were calculated as the difference between the total soluble sugars and reducing sugars. Starch from the sugar free pellet obtained after centrifugation was estimated by the method of Clegg (1956), and total available carbohydrates were calculated as the sum of total soluble sugars and starch.

Total lipids and their fatty acid composition

Total lipids were extracted by the method of Folch *et al.* (1957), and their fatty acid composition was determined by GLC, using the method of Luddy *et al.* (1968).

Total and extractable minerals

The samples for total and extractable minerals (Peterson *et al.*, 1943) were digested with a diacid mixture (nitric acid–perchloric acid, 4:1 (v/v)). Total and extractable calcium and phosphorus were determined titrimetrically (AOAC, 1980) and colorimetrically (Chen *et al.*, 1956), respectively, and iron, zinc, manganese and copper by atomic absorption spectrophotometry (Osis *et al.*, 1969).

Antinutritional factors

Trypsin inhibitor activity was assayed by the modified methods of Roy & Rao (1971). One unit of trypsin was defined as the amount of enzyme which converted 1 mg casein to trichloroacetic acid soluble components at 37°C in 20 min at pH 7·6. One unit of trypsin inhibitor activity was that which reduced the activity of trypsin by one unit under the assay conditions. Phytic acid was extracted in 0·5 M HNO_3 and estimated by the method of Davies & Reid (1979). Total polyphenols were extracted by the method of Singh & Jambunathan (1981) and estimated as tannic acid equivalent according to the Folin and Denis procedure (Swain & Hills, 1959). Saponins were extracted and determined by the modified method of Gestetner *et al.* (1966). Haemagglutinating activity was assayed by the method of Liener (1955).

All the estimations were carried out in triplicate and the data were subjected to statistical analysis of variance according to standard methods (Panse & Sukhatme, 1961).

RESULTS AND DISCUSSION

Proximate composition

Some significant (P = 0·05) varietal differences in contents of protein, crude fibre, riboflavin and ascorbic acid of rice bean varieties were observed (Table 1), while on the other hand, moisture, fat and ash contents of different varieties of rice bean did not differ significantly among themselves. Green gram and black gram has significantly (P = 0·05) higher concentrations of protein and fat, but lower amounts of ash and ascorbic acid than that of rice bean. All the legumes studied had similar contents of moisture and riboflavin. However, green gram had significantly (P = 0·05) lower values of crude fibre. Similar values of protein, fat, ash and crude fibre have been reported for rice bean and other legumes (Singh *et al.*, 1976; Chandel *et al.*, 1978; Singh *et al.*, 1980).

Table 1. Proximate composition and vitamin content of rice bean, green gram and black gram

Varieties	Moisture	Protein	Fat	Ash	Crude fibre	Riboflavin	Ascorbic acid
	(g/100 g)					(mg/100 g)	
Rice bean							
RB-4	10·34	17·2	0·48	4·40	6·64	0·36	1·32
RB-32	10·36	17·5	0·52	4·42	7·72	0·25	1·44
RB-37	10·49	18·5	0·46	4·18	7·45	0·35	1·61
RB-40	10·60	18·1	0·44	4·47	6·80	0·28	1·43
RB-53	10·28	18·1	0·56	4·42	6·84	0·33	1·20
Green gram							
K-851	10·81	20·6	1·31	3·36	4·86	0·37	0·94
Black gram							
MT-9	11·07	20·2	1·67	3·64	7·19	0·32	0·94
SE (m)	0·19	0·14	0·05	0·02	0·06	0·005	0·03
CD (P = 0·05)	NS	0·42	0·15	0·07	0·18	0·02	0·10

NS = not significant.

Table 2. Total soluble sugar, reducing sugar, nonreducing sugar, starch and total available carbohydrates in rice bean, green gram and black gram (on dry matter basis)

Varieties	Total soluble sugar (g/100 g)	Reducing sugar (mg/100 g)	Nonreducing sugar (g/100 g)	Starch (g/100 g)	Total available carbohydrates (g/100 g)
Rice bean					
RB-4	5·6	278	5·3	54·5	60·1
RB-32	5·6	418	5·1	52·9	58·5
RB-37	4·8	359	4·4	55·1	59·9
RB-40	5·1	312	4·9	53·9	59·4
RB-53	5·0	333	4·7	52·4	57·4
Green gram					
K-851	5·9	227	5·7	50·3	56·2
Black gram					
MT-9	3·3	188	3·1	49·1	52·4
SE (m)	0·06	7·9	0·05	1·06	1·03
CD (P = 0·05)	0·17	23·9	0·15	3·21	3·12

Carbohydrates

Total soluble sugars, nonreducing sugars, starch and total available carbohydrates of rice bean varieties varied from 5·0 to 5·6, 4·4 to 8·3, 52·4 to 60·1 g/100 g, respectively (Table 2). In the case of starch and total available carbohydrates, there were no significant varietal differences, whereas some significant varietal variations were observed in respect to total soluble sugars, reducing sugars and nonreducing sugars. Black gram had significantly (P = 0·05) lower values of sugars, starch and total available carbohydrates than that of rice bean, whereas green gram had significantly (P = 0·05) higher contents of total sugars and nonreducing sugars.

Fatty acid composition

Palmitic acid was the principal fatty acid constituting about 40 to 45% of total fatty acids in the legumes studied (Table 3). The total content of saturated fatty acids was more than 50%. Linoleic acid was the main unsaturated fatty acid, contributing about one-fourth of the total fatty acids. The other two unsaturated fatty acids (oleic and linolenic acids) constituted about 20% total fatty acids. The total unsaturated fatty acids ranged from 45·0 ± 0·3 to 49·5 ± 0·2%. The different varieties of the rice bean had almost similar composition of fatty acid except RB-53, which had slightly lower values of palmitic acid, total saturated fatty acids and linoleic acid, but higher values of linolenic acid and total unsaturated fatty acids. Plamitoleic acid was detected in traces in all the pulses.

When the fatty acid composition of rice bean was compared with green gram and black gram, it was observed that green gram had higher values of stearic acid, total saturated fatty acids and linoleic acid, but a lower content of linolenic acid and total unsaturated fatty acids. Black gram has a similar composition of

Table 3. Fatty acid composition of rice bean, green gram and black gram (% of total fatty acids detected)[a]

Varieties	Saturated fatty acids		Total saturated fatty acids	Unsaturated fatty acids			Total unsaturated fatty acids
	Palmitic acid	Stearic acid		Oleic acid	Lenoleic acid	Linolenic acid	
Rice Bean							
RB-4	42·8 ± 0·4	9·9 ± 0·3	52·7 ± 9·4	12·8 ± 0·4	24·3 ± 0·6	10·2 ± 0·2	47·3 ± 0·3
RB-32	42·1 ± 0·7	11·8 ± 0·7	53·9 ± 0·2	11·0 ± 0·2	25·7 ± 0·2	9·4 ± 0·1	36·1 ± 0·2
RB-37	44·6 ± 1·0	10·4 ± 0·1	55·0 ± 0·1	11·6 ± 0·3	24·9 ± 0·2	8·5 ± 0·4	45·0 ± 0·3
RB-40	43·2 ± 0·6	11·3 ± 0·4	11·7 ± 0·2	13·4 ± 0·4	23·4 ± 0·4	10·4 ± 0·2	45·5 ± 0·4
RB-53	40·5 ± 1·0	10·0 ± 0·2	50·5 ± 0·2	12·3 ± 0·2	21·9 ± 0·5	15·3 ± 0·2	49·5 ± 0·2
Green Gram							
K-851	46·1 ± 0·5	16·7 ± 0·4	62·8 ± 0·6	11·6 ± 0·3	17·5 ± 0·2	8·1 ± 0·1	37·2 ± 0·1
Black gram							
MT-9	39·6 ± 0·2	29·8 ± 0·2	69·4 ± 0·2	14·6 ± 0·2	10·4 ± 0·1	5·6 ± 0·1	30·6 ± 0·2

[a] Mean ± SD.

Table 4. Total and extractable calcium, phosphorus, iron, zinc, copper and manganese contents of rice bean, green gram and black gram (mg/100 g, on dry matter basis)

Varieties	Calcium		Phosphorus		Iron		Zinc		Copper		Manganese	
	Total	Extractable	Total	Extractable	Total	Extractable	Total	Extractable	Total	Extractable	Total	Extractable
Rice bean												
RB-4	307	273 (88·9)	238	77·8 (32·7)	6·7	5·7 (85·1)	3·2	2·1 (65·7)	1·8	1·1 (61·1)	3·0	2·2 (73·3)
RB-32	313	267 (85·3)	244	82·3 (33·6)	6·7	5·6 (83·6)	3·1	2·0 (64·5)	1·2	0·8 (66·7)	3·5	2·5 (74·3)
RB-37	287	240 (83·6)	234	77·4 (32·9)	6·3	5·3 (84·4)	2·8	1·9 (67·5)	1·3	8·8 (61·5)	2·5	1·9 (76·0)
RB-40	300	260 (86·7)	249	84·1 (33·7)	7·7	6·5 (84·4)	3·2	2·0 (62·5)	1·6	1·0 (62·5)	2·6	1·9 (73·1)
RB-53	327	287 (86·7)	244	81·7 (33·7)	6·3	5·3 (84·1)	3·1	1·9 (64·5)	1·4	0·8 (67·2)	1·9	1·6 (71·4)
Green gram												
K-851	140	117 (88·6)	299	87·1 (28·8)	8·6	7·2 (83·7)	3·5	2·5 (72·3)	1·4	0·9 (67·1)	1·9	1·6 (73·6)
Black gram												
MT-9	167	131 (79·6)	295	84·3 (28·5)	9·3	7·7 (82·8)	3·7	2·6 (70·2)	1·2	0·8 (66·6)	2·6	1·9 (73·1)
SE (m)	8·32	6·12	2·91	—	0·55	0·45	0·03	0·24	0·16	0·06	0·18	0·17
CD ($P = 0·05$)	25·4	18·8	8·89	NS	1·70	1·38	0·09	0·73	0·50	0·20	0·55	0·52

Values in parentheses indicate percentage extractability of total values.
NS = Not significant.

Table 5. Antinutritional factors of rice bean, green gram and black gram (on dry matter basis)

Varieties	Trypsin inhibitor activity (per g)	Phytic acid (mg/100 g)	Total polyphenols (mg/100 g)	Saponins (mg/100 g)	Haemagglutinins
Rice bean					
RB-4	35	2050	1279	2192	Present
RB-32	42	2270	1587	2292	Present
RB-37	49	1975	1286	2450	Present
RB-40	40	1875	1378	2317	Present
RB-53	36	1996	1441	2175	Present
Green gram					
K-851	42	937	1069	1542	Present
Black gram					
MT-9	43	1321	1073	1683	Present
SE (m)	0·5	15	5	27	
CD (P = 0·05)	1·4	45	15	84	

fatty acids except for palmitic, linoleic and total unsaturated fatty acids, which were even lower than that of green gram. Similar results for the fatty acid composition of green gram and black gram have been reported by Singh *et al.* (1976). The fatty acid profile of rice bean varieties reveals that it contains more unsaturated fatty acids than the traditional legumes.

Total and extractable minerals

The concentrations of calcium, phosphorus, iron, zinc, copper and manganese of rice bean varieties varied from 287 to 327 and 234 to 249, 6·3 to 7·7, 2·8 to 3·2, 1·2 to 1·8 and 1·9 to 3·5 mg/100 g, respectively (Table 4). Some of the rice bean varieties differed significantly in total and extractable minerals. RB-37 had the lowest total and extractable calcium, phosphorus and zinc. In rice bean the extractability of calcium was the highest (about 88%) and phosphorus was the lowest (33%). Green gram and black gram had significantly (P = 0·05) lower total and extractable calcium, but slightly higher levels of phosphorus, iron and zinc than those of rice bean. The concentrations of other minerals were comparable in all the legumes studied. The present study shows that rice bean is a good source of minerals, and extractability of these minerals is quite high.

Antinutritional factors

Trypsin inhibitor activity (TIA), phytic acid, total polyphenols and saponin contents of rice bean varieties ranged from 36 to 55 (TIA/g), 1975 to 2270, 1286 to 1387 and 2175 to 2450 mg/100 g, respectively (Table 5). All the rice bean varieties differed significantly (P = 0·05) in antinutritional factors. Both green gram and black gram had significantly (P = 0·05) lower values of all the antinutritional factors than those of rice bean.

The present results strengthen the earlier contention that all legumes studied to date contained trypsin inhibitors in varying amounts (Liener & Kakade, 1969). Phytic acid has been known to be the major storage form of phosphorus, and in dry legumes it has been reported to vary from 0·44 to 1·46% (Reddy *et al.*, 1982). Phytic acid is known to be involved in undesirable processes including those leading to hard cook (Boutler, 1962). This adverse attribute increases cooking time and is important to people in developing countries where energy sources including fuel wood are becoming increasingly scarce and expensive.

The rice bean varieties (RB-32, RB-40 and TB-53) having a dark colour seed coat had a higher concentration of polyphenols than those having a light colour (RB-4 and RB-27). The concentration of tannins in the seed of the legumes thus seems to be a function of the colour of the seed coat (Bressani & Elias, 1980; Deshpande *et al.*, 1982; Deshpande & Cheryan, 1983). Tannins form complexes with proteins, carbohydrates and other polymers in food as well as with certain metal ions such as iron under suitable conditions and appropriate pH. The greater tendency of tannins to form complexes with proteins than with carbohydrates and other food polymers may explain the low digestibility of legume protein.

Saponin, an important constituent of the legume seeds, when taken in appropriate amounts in the diet, is likely to play a significant role in lowering plasma cholesterol in man (Topping *et al.*, 1980). Haemagglutinating activity in the present study was determined qualitatively and was found to be present in all the three legumes studied. Lactins, the heat-labile toxic factor of many foods including legume seeds, may be responsible for rendering these foods unsuitable for human consumption unless properly cooked.

The findings of the present study reveal that nutrient profiles of different varieties of rice bean differ, indicating that there are genetic variations. However, they are comparable with traditional legumes such as green gram and black gram. Therefore, production and consumption of rice bean should be encouraged as it is nutritionally useful and it has a great yield potential under adverse agroclimatic conditions.

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