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Some Antinutritional Factors in Rice Bean (*Vigna umbellata*): Effects of Domestic Processing and Cooking Methods

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ABSTRACT

*The present investigation was conducted to study the concentration of polyphenols, phytic acid and saponins of five high-yielding varieties of rice bean (*Vigna umbellata*) and one variety each of green gram and black gram as affected by various domestic processing and cooking methods which included soaking in tap water for 6, 12 and 18 h; sprouting for 40 and 60 h; ordinary cooking of unsoaked and soaked seeds; and autoclaving of unsoaked and soaked seeds. There was a successive and significant reduction in the contents of antinutritional factors with increase in soaking and sprouting period. A markedly greater reduction in these factors was observed when soaked seeds were cooked and autoclaved than when unsoaked seeds were cooked and autoclaved. Among the various domestic processing and cooking methods, maximum reduction of antinutritional factors was observed when soaked seeds were autoclaved.*

INTRODUCTION

Legumes are a major source of dietary proteins in developing countries. However, in some parts of the world, *per capita* consumption of legumes has recently decreased. In order to meet the requirement of the pulse protein, efforts have been made to increase the production of legumes through breeding strategies. However, greater attention is now being paid to the

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exploration of non-conventional pulses such as rice bean, jack bean, etc. Rice bean, as a grain legume, is attracting attention throughout the world as a potential source of high quality protein for the future. Legumes are usually processed and then consumed. The most common method of processing is over-night soaking and then cooking until they are soft. The other methods of preparation include sprouting, cooking, parching and fermentation (Rockland *et al.*, 1979).

Legumes contain a number of toxic factors which reduce their nutritive value (Salunkhe, 1982). The information on this aspect of rice bean (now being introduced by the plant breeders) for human consumption is scanty. Thus, it becomes imperative to know, not only the nutrient composition and antinutritional factors in raw rice bean, but the extent to which these factors survive domestic processing and cooking treatments. The present study was therefore conducted to investigate the concentration of antinutritional factors as affected by different processing methods.

MATERIALS AND METHODS

Materials

The grains of five high-yielding varieties (RB-4, RB-32, RB-37, RB-40 and RB-53) of rice bean (*Vigna umbellata*) and one variety each of green gram (K-81) and black gram (MT-9) were obtained from the Department of Plant Breeding, Haryana Agricultural University, Hisar. Seeds were thoroughly cleaned and freed from broken seeds, dust and other foreign materials. Green gram and black gram have been included in this study as controls because these pulses are most acceptable and widely consumed.

Processing and cooking methods

Soaking in tap water

Seeds were soaked in tap water (seed:water, 1:5 w/v) for 6, 12 and 18 h at room temperature (30°C). The water left after soaking was discarded. The soaked seeds were washed twice with ordinary water followed with distilled water and then dried at 60°C. Dried samples were ground in a Cyclotec Sample Mill (60 mesh) and then stored for further chemical analysis.

Sprouting

The seeds were taken in sterile Petri plates lined with wet filter paper and kept in an incubator at 30°C for 40 and 60 h. The sprouted samples were dried at 60°C, ground and used for analysis. The sprouted sample of black gram could not be prepared because of growth of fungus during sprouting which appeared repeatedly in the samples.

Ordinary cooking
The seeds, soaked for 12 h and unsoaked seeds, were cooked in beakers. The ratio of seed to water in the case of soaked seeds was 1:5 (w/v) and in the case of unsoaked seeds 1:6 (w/v) on the basis of dry seed weight. The water was allowed to boil before the addition of seeds. The seeds were cooked until soft when felt between fingers. The cooking time for soaked seeds was 10 min and unsoaked seeds, 15 min. The cooked samples were dried and stored for chemical analysis.

Autoclaving
The seeds soaked for 12 h and unsoaked seeds were both autoclaved at 1·05 kg/cm² for 5 and 10 min, respectively. The ratio of seed to water was 1:5 (w/v) for unsoaked seeds and 1:4 (w/v) for soaked seeds. The autoclaved seeds were then mashed, dried at 65°C, finely ground and stored.

Analytical procedures

Total polyphenols were extracted by the method of Singh and Jambunathan (1981) and estimated as tannic acid equivalent according to the Folin Denis procedure (Swain & Hills, 1959). Phytic acid was extracted in 0·5 M nitric acid and estimated by the method of Davies and Reid (1979). Saponins were extracted and determined by the modified method of Gestetner *et al.* (1966). Data thus obtained were subjected to analysis of variance (Panse & Sukhatme, 1961).

RESULTS AND DISCUSSION

Polyphenols

Soaking for 6 h and 8 h caused a remarkable reduction (27·2–36·8%) in the polyphenolic contents of rice bean varieties which differed significantly ($P < 0{\cdot}05$) among themselves except for RB-4 and RB-40 (Table 1). When the soaking period was increased to 18 h there was a further reduction in the amounts of polyphenolic content of different varieties of rice bean, which varied from 42·2–52·3% (RB-32). The reduction in the concentration of polyphenolics of green gram and black gram during different periods of soaking was lower than that of rice bean.

TABLE 1

Effects of Soaking, Sprouting, Ordinary Cooking and Autoclaving on the Polyphenolic Content of Rice Bean, Green Gram and Black Gram (mg/100 g, on dry matter basis)

Varieties	*Raw pulse*	*Soaking (h)*			*Sprouting (h)*		*Ordinary cooking*		*Autoclaving*	
		6	12	18	40	60	*Unsoaked*	*Soaked*	*Unsoaked*	*Soaked*
Rice bean										
RB-4	1 279	889 (30·4)	831 (35·0)	731 (42·8)	879 (31·2)	829 (35·7)	1 070 (16·3)	795 (37·5)	1 004 (21·5)	689 (46·1)
RB-32	1 587	1 002 (36·8)	852 (46·3)	756 (52·3)	943 (40·5)	987 (44·1)	1 231 (22·4)	1 066 (32·8)	1 035 (34·7)	739 (53·4)
RB-37	1 286	887 (31·0)	812 (36·9)	729 (43·3)	889 (35·5)	825 (40·2)	995 (22·6)	722 (43·9)	939 (27·0)	602 (53·2)
RB-40	1 370	1 004 (27·2)	831 (32·7)	787 (42·9)	891 (35·3)	831 (39·7)	1 208 (12·4)	877 (36·4)	1 008 (26·9)	727 (42·3)
RB-53	1 441	925 (35·8)	877 (39·2)	760 (47·3)	960 (32·8)	885 (38·5)	1 110 (23·0)	831 (42·3)	1 006 (30·2)	747 (48·1)
Green gram										
K-851	1 865	883 (17·0)	810 (23·9)	745 (29·9)	941 (12·2)	883 (17·7)	743 (30·1)	556 (47·7)	658 (38·1)	606 (43·0)
Black gram										
MT-9	1 073	889 (17·1)	787 (26·6)	641 (40·2)	—	—	885 (17·5)	725 (39·4)	806 (24·8)	612 (42·9)

	Soaking	*Sprouting*		*Cooking*	*Autoclaving*
Varietal					
SE(m)	5·0	1·7	2·4	2·4	2·1
CD($P<0·05$)	14·3	5·1		7·0	6·2
Period					
SE(m)	3·2	1·0		1·2	1·1
CD($P<0·05$)	9·3	2·9		3·7	3·3
Varietal × Period					
SE(m)	8·7	6·1		3·4	9·2
CD($P<0·05$)	24·8	17·9		9·9	26·6

Values in parentheses indicate per cent decrease over control values (values of raw pulses).

A successive and significant ($P < 0.05$) reduction in polyphenol content was found in all the pulses with progressive increase in soaking period. Since polyphenolic compounds are present on the periphery of the grain, their passing out into the soaking medium through the seed coat is possible. This may explain the loss of polyphenols during soaking. A marked decrease in tannin equivalent of winged bean (Sathe & Salunkhe, 1981) and dry beans (Deshpande & Cheryan, 1983) has been observed.

After 40 h and 60 h sprouting, polyphenolic content of some varieties of rice bean was significantly ($P < 0.05$) higher than others. However, the reduction was markedly higher in rice bean than the green gram. Sprouting of seeds also brought about a successive and significant ($P < 0.05$) decrease in the polyphenolic content of all the pulses with increase in sprouting time. The loss of polyphenols during sprouting may be attributed to the presence of polyphenol oxidases and enzymatic hydrolysis (Rao & Deosthale, 1982). Some losses of polyphenols during germination may also be due to their leaching out into the water. Germination has been shown to decrease the tannin content of pigeon pea, chickpea, black gram and green gram (Rao & Deosthale, 1982). On cooking of unsoaked seeds, the amounts of polyphenolic compounds of rice bean varieties varied significantly ($P < 0.05$) among themselves. Cooking of soaked seeds brought a further reduction in the polyphenolic contents of all pulses. The results of the present study reveal that autoclaving was more effective than ordinary cooking in reducing the concentration of polyphenolic compounds of pulses. However, the reduction was lower in green gram and black gram than in rice bean.

Decrease in tannin content of the legume grains during cooking may be ascribed to the binding of polyphenols with other organic substances or to alterations in the chemical structure of polyphenols which cannot be extracted and determined by available methods. As ordinary cooking and autoclaving involves moist heating, polyphenols may be destroyed during these methods of processing. The results are in agreement with those reported by earlier workers (Rao & Deosthale, 1982; Reddy *et al.*, 1985; Ekpenyong, 1985).

Phytic acid

The phytic acid contents after soaking for 6, 12 and 18 h varied significantly ($P < 0.05$) among the rice bean varieties which were significantly ($P < 0.05$) higher than both green gram and black gram (Table 2). There was a successive and significant ($P < 0.05$) reduction in the phytic acid content of all the pulses with increase in soaking period from 6 to 18 h. This decrease in phytic acid content of legume seeds during soaking can be attributed to leaching of phytate ions into soaking water under the influence of

TABLE 2

Effects of Soaking, Sprouting, Ordinary Cooking and Autoclaving on the Phytic Acid Content of Rice Bean, Green Gram and Black Gram (mg/100 g, on dry matter basis)

Varieties	*Raw pulse*	*Soaking (h)*			*Sprouting (h)*		*Ordinary cooking*		*Autoclaving*	
		6	*12*	*18*	*40*	*60*	*Unsoaked*	*Soaked*	*Unsoaked*	*Soaked*
Rice-bean										
RB-4	2 060	1 745 (14·8)	1 565 (23·8)	1 291 (36·7)	1 670 (18·5)	1 458 (41·0)	1 616 (21·1)	1 476 (28·0)	1 579 (23·0)	1 208 (41·0)
RB-32	2 270	1 875 (17·4)	1 575 (30·6)	1 112 (51·0)	1 866 (17·8)	1 679 (38·3)	1 720 (24·2)	1 416 (37·6)	1 483 (34·5)	1 209 (46·7)
RB-37	1 975	1 587 (19·6)	1 341 (32·1)	1 270 (35·6)	1 325 (32·9)	1 115 (48·9)	1 429 (27·6)	1 179 (40·3)	1 170 (40·11)	971 (50·8)
RB-40	1 875	1 758 (6·2)	1 483 (20·9)	1 291 (31·1)	1 620 (13·5)	1 212 (37·3)	1 404 (25·1)	1 100 (41·3)	1 241 (33·8)	1 003 (16·5)
RB-53	1 995	1 804 (26·2)	1 645 (17·5)	1 425 (28·6)	954 (52·2)	791 (50·3)	1 433 (28·2)	1 225 (38·9)	1 132 (40·8)	933 (52·2)
Green gram										
K-851	937	791 (15·5)	533 (43·1)	304 (67·8)	707 (24·9)	687 (26·7)	470 (49·8)	208 (77·2)	379 (59·5)	154 (83·3)
Black gram										
MT-9	1 321	1 020 (22·7)	979 (25·9)	850 (35·6)	—	—	1 120 (15·1)	741 (43·8)	1 091 (17·34)	675 (48·9)

	Soaking	*Sprouting*	*Cooking*	*Autoclaving*
Varietal				
SE(m)	11·4	4·8	6·1	5·8
CD($P < 0{\cdot}05$)	32·6	14·2	17·6	16·9
Period				
SE(m)	7·4	2·8	3·2	3·1
CD($P < 0{\cdot}05$)	21·3	8·23	9·4	9·0
Varietal × Period				
SE(m)	19·8	5·9	8·6	8·2
CD($P < 0{\cdot}05$)	56·5	20·1	29·9	23·2

Values in parentheses indicate per cent decrease over control value (values of raw pulses).

concentration gradient. Similar losses have been reported after soaking of different legume seeds (Deshpande & Cheryan, 1983; Ologhobo & Fetuga, 1984).

The phytic acid content varied significantly ($P < 0.05$) among the rice bean varieties on sprouting for 40 and 60 h. Phytic acid content decreased successively and significantly ($P < 0.05$) with increase in sprouting time in all the pulses. This loss of phytic acid during sprouting may be attributed to the development of phytase activity. Phytase has been shown to be active in seeds like faba beans during germination (Michael Eskin & Wiebs, 1983) and was reported to reduce the phytic acid content in cowpea, soybean and lima bean (Ologhobo & Fetuga, 1984), and horse gram and moth bean (Borade *et al.*, 1984).

Ordinary cooking of unsoaked and soaked seeds decreased the phytic acid content in all the pulses which varied significantly ($P < 0.05$) among the rice bean varieties. Cooking of soaked seeds caused a greater reduction in the phytic acid than cooking of unsoaked seeds.

Autoclaving of soaked seeds brought a marked reduction in phytic acid content of all the pulses. The decrease observed in phytic acid content due to cooking can be attributed to the formation of insoluble complexes between phytate and other components (Kumar *et al.*, 1978). Similarly, a decreasing effect of cooking and autoclaving on the phytic acid content of soybean, lima bean and cowpea has been observed (Ologhobo & Fetuga, 1984).

Saponins

The saponin content on 12 h soaking, 40 h sprouting and ordinary cooking of unsoaked seeds varied significantly ($P < 0.05$) among the rice bean varieties and was significantly ($P < 0.05$) higher than that of green gram and black gram (Table 3). The loss of saponin content of the seeds during soaking may be attributed to the leaching of saponin into the soaking medium through simple diffusion but the losses during cooking indicate the thermolabile nature of saponins. Whether cooking results in the formation of a poorly-extractable complex between saponins and sugars or amino acids is not known. The results here contradict the earlier report (Fenwick & Oakenfull, 1983) that saponins survive the rigours of cooking and heat processing.

The investigation indicates that the concentrations of polyphenols, phytic acid and saponins were high in rice bean compared to other pulses, but were considerably reduced through various domestic processing and cooking methods resulting in better utilisation of pulses. The plant breeders should, therefore, pay attention to genetic preparation of new varieties which have

TABLE 3
Effects of Soaking, Sprouting and Ordinary Cooking on the Saponin Content of Rice Bean, Green Gram and Black Gram (mg/100 g, on dry matter basis)

Varieties	*Raw pulses*	*Soaking 12 h*	*Sprouting 40 h*	*Ordinary cooking*
Rice bean				
RB-4	2 192	2 058	1 850	1 867
		(6·1)	(15·2)	(14·8)
RB-32	2 292	2 158	1 878	1 842
		(5·8)	(18·2)	(19·6)
RB-37	2 450	2 300	1 958	1 975
		(6·1)	(20·1)	(19·4)
RB-40	2 317	2 233	1 859	1 892
		(3·6)	(19·7)	(18·3)
RB-53	2 175	2 067	1 725	1 775
		(5·0)	(20·7)	(18·4)
Green gram				
K-851	1 542	1 475	1 117	1 113
		(4·3)	(27·5)	(26·5)
Black gram				
MT-9	1 683	1 550	—	1 167
		(7·9)		(30·7)
SE (m)	27·7	14·8	27·1	15·1
CD ($P < 0{\cdot}05$)	84·1	43·4	80·9	44·4

Values in parentheses indicate per cent decrease over control values (values of raw pulses).

smaller concentrations of antinutritional factors. Of the domestic processing and cooking methods, autoclaving of soaked seeds had the most pronounced effect in decreasing the content of phytic acid and polyphenols followed by soaking for 18 h. Thus, rice bean should be consumed preferably after soaking and pressure cooking.

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