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Effect of presoak treatment on cooking characteristics and nutritional functionality of rice bean

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ABSTRACT

The effect of soaking rice bean on proximate composition, cooking characteristics, phytic acid, polyphenols content and functional properties were investigated. This study aimsed at comparing the changes that occured on soaking of blanched rice bean seeds in distilled water for 12 h and in salt solution (1.5% $NaHCO_3$, 0.5% Na_2CO_3 and 0.75% citric acid, pH 7.0 ± 0.1) for 3, 6, 9 and 12 h each. Soaking, significantly ($P < 0.05$) increased the water absorption and dispersal of solids while it decreased the cooking time following increase in time of soaking. The anti-nutrients *viz.*, polyphenols and phytic acid significantly decreased during soaking. The decrease in phytic acid was higher in salt solution soaking as compared to distilled water soaking. Soaking of beans for 12 h in different solutions did not show remarkable changes in proximate composition of rice bean flours. But foaming and emulsifying properties, nitrogen solubility and PCMP number showed a negative correlation, whereas, bulk density, water and oil absorption capacity showed a positive correlation with soaking time.

Key words: Anti-nutrients, Cooking characteristics, Functional properties, Presoak treatment, Rice bean

Rice bean is a rich source of nutrients. There are many reports although indicate that the protein content in rice bean is in lower range as compared to other pulses yet its bioavailability is high. As in other pulses, an important problem with rice bean is that it contains various anti-nutrients, notably phytic acid and polyphenols that reduce the uptake of several micronutrients. Kaur and Kapoor (1992) reported in rice bean that the poylphenolic content varied between 1279 and 1587 mg and phytic acid content between 1875 and 2270 mg/100 g. Saikia *et al* (1999) observed phytic acid ranged from 1998 to 2170 mg/100 g in five varieties of rice bean.

Soaking of beans facilitates quicker cooking. Soaking and cooking of legumes result in significant reduction in phytic acid and tannin contents. Maximum reduction of phytic acid (78.05%) and tannin (65.81%) was found for sodium bicarbonate soaking followed by cooking. These treatments also result in a slight reduction in nutrients such as protein, minerals and total sugars (Iyer *et al*. 1980). The effects of presoaking of pulses in the salt solution of several chemicals in reducing the cooking time of pigeonpea splits (Narsimha and Desikachar 1978a), peas (Bongirwar and Sreenivasan 1977), beans (Rockland and Mertzler 1967, Iyer *et al*. 1980), winged bean (Narayana 1981), pigeon pea, chickpea, black bean, mung bean and lentil splits (Chavan *et al*. 1983) and moth bean (Pawar and Ingle 1986) were also reported. Thus, the current investigation was carried out to study the effect of presoak treatment with distilled water *vis-à-vis* salt solution on proximate composition, cooking characteristics, antinutrients and nutritional functionality of rice bean.

MATERIALS AND METHODS

In the present investigation, seeds of rice bean (*Vigna umbellata*) were obtained from the Department of Agricultural Botany, MPKV, Rahuri. These were cleaned for extraneous matter and stored in clean glass bottles at 4^0C, until use. Quick cooking beans were prepared as per the procedures described by Rockland and Mertzler (1967). One lot was soaked in distilled water for 12 h and the unsoaked sample was taken as the control. The soaked beans were cooked traditionally in distilled water at 100 ^{0}C (beans to water ratio was 1:4 in terms of weight/ volume) until these were softened to a uniform mass when pressed between thumb and forefinger (Sharma *et al.* 1977) for determination of cooking time. The proximate composition of unsoaked rice bean such as moisture, protein, fat, ash and carbohydrates of the bean was determined as per AOAC (2000) procedures. The rate of hydration, dispersed solids and cooking time were determined as per the procedures of Narasimha and Desikachar (1978). The PCMP number was calculated by the following formulae.

PCMP = pectin (Ca + Mg/2) /phytin or pectin + (Ca +Mg/2) – phytin.

The pectin, calcium and magnesium content were estimated according to standard procedure of AOAC (2000).

Anti-nutrient factors like, polyphenolic content was estimated according to the method of AOAC (2000). Extraction and precipitation of phytate phosphorus were performed according to the method of Wheeler and Ferrel (1981). Phytate phosphorus estimation was carried out according to the method of Makower (1970). The iron content was measured by the AOAC(2000) method using O-phenanthroline reagent. On the basis of phytate phosphorus contents, the phytic acid was calculated assuming 28.20% phosphorus in the molecule.

Functional properties such as water and oil absorption capacities were determined by the procedure of Beuchat *et al.* (1977).The least gelation concentration was determined by method of Coffman and Garcia (1977) with slight modifications as described by Deshpande *et al.* (1982). Nitrogen solubility was determined as per standard procedure. The foaming properties such as foaming capacity was determined according to method of Coffman and Garcia (1977) while specific volume of foams was determined as an index of air uptake during whipping and weights were taken before and after whipping and specific volumes calculated according to method by Baldwin and Sinthavalai (1974).The emulsion properties such as emulsifying activity and emulsifying stability of the samples were determined by the method of Yasumatsu *et al.* (1972) with slight modifications as described by Deshpande *et al.* (1982). The bulk density was determined according to Okezie and Bello (1988).

***Statistical analysis*:** The analysis of triplicate data as a function of treatment levels was done to determine significant difference ($P < 0.05$) by computing standard error and critical difference by using methods of Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

***Change in proximate and chemical composition of flours*:** A net loss of dry weight occurred as a result of soaking and oxidation of stored compounds with a gradual increase of moisture (Table 1). At the end of 12 h soaking period, per cent moisture content of the bean increased from the initial 10.3 to 11.4 and 11.7 for distilled water and salt solutions, respectively. There was a significant decrease in total carbohydrate content during soaking of rice bean. Similar observations were reported by Zacharie and Ronald (1995) on common beans. The total ash content also gradually decreased throughout the soaking period. Rao and Deosthale (1983) also reported loss in ash content of mungbean and urdbean during overnight soaking in distilled water due to leaching of total minerals in the soaking medium. Per cent protein content of bean also decreased significantly from 17.5 to 15.4 and 15.2 during soaking for 12 h in distilled water and salt solution, respectively.

Little changes in the concentration of pectin, Ca and Mg were observed due to soaking while greater change in the concentration of phytate was found. Sample soaked in salt solution for 12 h showed a significant decrease in pectin, Ca, Mg, phytate and PCMP number from 3.82 to 2.92 mg/g, 2.58 to 1.79 mg/g, 0.72 to 0.51 mg/g, 21.72 to 12.39 mg/g and 0.514 to 0.479, respectively.

The hard-to-cook defect in legume seeds is based on PCMP number which represents pectin insolubilization *via* binding with divalent cations (e.g. Ca^{2+}, Mg^{2+}) resulting from phytate breakdown by phytase. The effect of soaking on rice bean in a salt solution containing Na^{+} cations or distilled water decreased the amount of pectin and was associated with divalent cations that led to insoluble form reducing the PCMP

Table 1. Effect of Soaking on Proximate composition, pectin, calcium, magnesium, phytate and PCMP number of rice bean flours

Treatment	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)	Pectin (mg/g)	Calcium (mg/g)	Magnesium (mg/g)	Phytate (mg/g)	PCMP number
Unsoaked	10.3	17.5	0.51	4.5	61.6	3.82	2.58	0.72	21.72	0.514
Soaking [a]	11.4	15.4	0.49	4.4	60.1	3.05	1.83	0.54	19.56	0.322
Soaking [b]										
3 h	10.5	16.9	0.48	4.4	61.0	3.63	2.35	0.69	18.97	0.511
6 h	10.9	16.4	0.46	4.4	60.5	3.42	2.13	0.64	16.76	0.497
9 h	11.5	15.8	0.48	4.4	60.2	3.22	1.95	0.58	14.52	0.493
12 h	11.7	15.2	0.47	4.3	60.0	2.92	1.79	0.51	12.39	0.479
SEm(±)	0.07	0.05	0.005	0.007	0.08	0.03	0.02	0.01	0.09	0.007
CD(P=0.05)	0.21	0.17	0.01	0.02	0.2	0.10	0.07	0.04	0.28	0.022

Soaking[a]: Soaking in distilled water for 12 h at 27 ^{0}C; Soaking[b]: Soaking in mixed salt solution at 27 ^{0}C

Table 2. Effect of soaking on cooking characteristics and functional properties of rice bean flours

Treatment	Rate of hydration (g/100g)	Dispersed solids (g/100g)	Cooking time (min)	Reduction in cooking time (%)	Water absorption capacity (g/g)	Oil absorption capacity (g/g)	Foaming capacity (%)	Specific volume (ml/g)
Unsoaked	-	-	30	-	2.40	1.45	25	1.27
Soaking [a]	166.6	21.8	10	66.7	2.41	1.45	21	1.21
Soaking [b]								
3 h	49.5	9.7	25	16.6	2.39	1.45	24	1.25
6 h	62.9	13.7	20	33.3	2.41	1.50	22	1.22
9 h	101.4	17.6	15	50.0	2.44	1.55	21	1.21
12 h	142.7	21.6	8	73.3	2.50	1.58	19	1.18
SEm(±)	1.22	0.787	0.47	-	0.03	0.007	0.47	0.05
CD(P=0.05)	3.84	2.48	1.45	-	0.10	0.02	1.45	0.01

Soaking[a]: Soaking in distilled water for 12 h at 27 ^{0}C; Soaking[b]: Soaking in mixed salt solution at 27 ^{0}C number and hardness of the bean. Bicarbonate and carbonate of sodium salt solution have solubilizing effect on the pectic substances that facilitates easy penetration and faster hydration on interior starch and protein molecules resulting into quick cooking beans.

***Change in cooking characteristics and functional properties*:** It was observed that rate of water uptake and leaching losses of total solids were higher when beans were soaked in distilled water, but lower when soaked in salt solution (Table 2). However, the rates of water uptake and leaching losses of total solids increased progressively when beans were soaked in salt solution for 3, 6, 9 and 12 h. Rate of hydration and dispersed solids were also found significant in case of 12 h distilled water soaked sample than that of salt solution. Iyer *et al.* (1980) also observed increased rate of both hydration and leaching losses with increased soaking time with mixed salt solution from 6 to 24 h in Great Northern, Kidney and Pinto beans.

Moreover, time required for cooking blanched rice bean was 30 min (Table 2) when the beans to cooking water ratio were 1.4 (wt/vol). When the beans were soaked in distilled water for 12 h or in salt solution for 3, 6, 9 and 12 h, the time required for cooking significantly decreased from 30 min to 10, 25, 20, 15 and 8 min, respectively. A significant decrease in cooking time was found in 12 h salt soaked sample compared to 12 h distilled water soaked sample. The beans soaked in distilled water and salt solution for 12 h caused reduction in cooking time by 66.7% and 73.3%, respectively.

In the present study, the pretreatment of seeds, duration of soaking and type of soaking solution influenced the cooking time. Increased reduction in cooking time observed by soak treatment of blanched seeds in salt solutions than in distilled water might be due to the presence of cations in the soaking medium that increased the softening rate (as a result of ion exchange and probably by chelation of ions resulting in solubilization of pectin substances). Kadam *et al.* (1981) reported 67% reduction in cooking time of moth bean when soaked in a mixed salt solution for 12 h. Narayana (1981) reported that soaking the winged bean splits in salt solution for 2 h reduced the cooking time by nearly 50%.

Similarly, soaking in salt solution for 12 h had a significant water absorption capacity (2.5 g/g flour) than soaking in distilled water (Table 2) for 12 h (2.4 g/g flour). Although there was apparent decrease in protein content in salt soaked flours, yet the water absorption capacity increased significantly due to dissociation of proteins during blanching of rice bean before soaking in salt solution.

Change in nitrogen solubility: Unsoaked rice bean flour had minimum N solubility of 12% at pH 5 (Fig 1). However, at pH 3.0, about 60% of nitrogen was soluble and at *p*H 12 it was about 90%. In the present investigation, N solubility of raw and 12 h distilled water soaked rice bean flours was increased even beyond *p*H 10 although there was no significant improvement in N solubility in rest of the cases (salt soaked samples). However, it remained more or less constant up to pH 12.0. Moreover, as the time of soaking in salt solution increased the solubility of N decreased at all pH levels in all soaked flours. Decrease in N solubility of 12 h water soaked rice bean flour might be due to decrease in protein content.

***Changes in foam stability*:** The decrease of total volumes after soaking rice bean in distilled water and salt solution for 12 h was 9.09 and 9.2%, respectively compared to 7.2% of raw rice bean flour (Table 3) while the corresponding decrease in

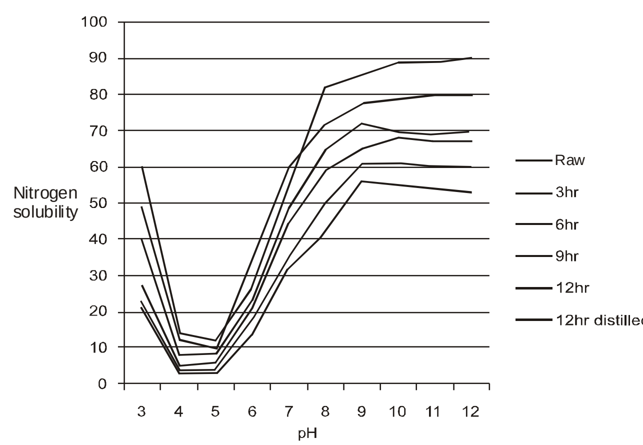

Fig 1. Effect of soaking on the nitrogen solubility (%) of rice bean flours

Table 3. Foam stability of soaked rice bean flours

Treatment	0 min		30 min		60 min		90 min		120 min		% decrease in volume	
	Total	Foam	Total	Foam	Total	Foam	Total	Foam	Total	Foam	Total	Foam
Raw	125	33	124	31	121	29	118	27	116	23	7.20	30.3
Soaking[a]	121	29	118	27	116	25	113	21	110	18	9.09	37.9
Soaking[b]												
3 h	124	32	122	30	120	26	118	24	114	21	8.06	34.3
6 h	122	30	120	28	116	26	113	22	111	19	9.01	36.6
9 h	121	29	119	27	115	25	113	21	110	18	9.09	37.9
12 h	119	27	116	25	113	23	111	21	108	16	9.20	40.7
SEm(±)	0.47	0.47							0.52	0.52		
CD(P=0.05)	1.45	1.45							1.62	1.62		

Soaking[a]: Soaking in distilled water for 12 h at 27 ^{0}C ; Soaking[b]: Soaking in mixed salt solution at 27 ^{0}C

Table 4. Effect of soaking on emulsion activity and stability of rice bean flours

Treatment	Emulsifying activity (%)	Emulsifying stability (%)	Bulk density (g/ml)	% increase of bulk density
Unsoaked	52.40	49.22	0.582	-
Soaking[a]	42.44	40.44	0.642	10.34
Soaking[b]				
3 h	46.58	44.23	0.592	1.72
6 h	44.76	42.46	0.614	5.17
9 h	43.24	41.28	0.638	8.62
12 h	41.82	38.77	0.651	12.06
SEm(±)	0.47	0.08	0.005	-
CD(P=0.05)	1.46	0.27	0.012	-

Soaking[a]: Soaking in distilled water for 12 h at 27 ^{0}C; Soaking[b]: Soaking in mixed salt solution at 27 ^{0}C

foam volume was 37.9, 40.7 and 30.3%, respectively. Thus, the foam stability was comparatively more in raw rice bean flours than water or salt soaked rice bean flours.

***Change in emulsion properties and bulk density*:** Emulsifying activity of unsoaked dry rice bean flour sample was 52.4% which decreased significantly ($P < 0.05$) on soaking rice bean either in distilled water or salt solution (Table 4). As the time of soaking in salt solution increased from 3 to 12 h, the emulsion properties decreased significantly. Bulk density of raw rice bean flour was also increased from 0.582 to 0.651 and 0.642 g/ml following 12 h soaking with salt solution and distilled water, respectively.

***Effect of soaking on anti-nutrients of rice bean flours*:** The polyphenols expressed as tannic acid decreased significantly from 9.62 to 6.37 and 5.77 mg/g in rice beans soaked in distilled water and salt solution for 12 h respectively. The reduction of polyphenols on soaking in salt solution increased progressively with time of soaking. Kaur and Kapoor (1992) observed a remarkable reduction (27.2-36.8%) in the polyphenolic contents of rice bean when soaked for 6 h and 8 h in distilled water.

The phytic acid content also decreased significantly from 21.72 mg/g to 12.39 mg/g and 19.56 mg/g when rice beans were soaked for 12 h in salt solution and distilled water, respectively (Table 5). The rice beans soaked in salt solution for 3 h also showed a remarkable decrease in phytic acid (12.66%) when compared with beans soaked in distilled water for 12 h. Thus, the beans soaked in salt solution for 12 h showed a significant decrease in phytate content compared to other salt soaked and distilled water soaked samples (Kaur and Kapoor 1992, Deshpande and Cheryan (1983). This decrease in phytic acid in legume seeds during soaking can be attributed to leaching of phytate ions into soaking water under the influence of concentration gradient.

Table 5. Effect of soaking on polyphenolic content, phytate phosphorus and phytic acid of rice bean flours

Treatment	Polyphenols (mg/g)	Reduction in polyphenols (%)	Phytate phosphorus (mg/g)	Phytic acid (mg/g)	Reduction of phytic acid (%)
Unsoaked	9.62	-	6.12	21.72	-
Soaking [a]	6.37	33.7	5.51	19.56	9.94
Soaking [b]					
3 h	8.12	15.5	5.34	18.97	12.66
6 h	6.62	31.1	4.72	16.76	22.83
9 h	6.12	36.3	4.08	14.52	33.14
12 h	5.77	40.0	3.48	12.39	42.95
SEm(±)	0.04	-	-	0.09	-
CD(P=0.05)	0.13	-	-	0.28	-

Soaking[a]: Soaking in distilled water for 12 h at 27 ^{0}C; Soaking[b]: Soaking in mixed salt solution at 27 ^{0}C

The study suggested that the anti-nutrients such as polyphenols and phytic acid (along with N solubility, foaming and emulsifying properties) were decreased with soaking time whereas, the water and oil absorption capacity and bulk density of rice bean flours increased. The PCMP number also decreased with increase of soaking of rice bean in salt solution and had an advantage of improving the cooking quality characteristics, removal of antinutrients and functional properties over rice beans either unsoaked or soaked in distilled water.

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