Effect of Soaking on Functional Properties of Rice Bean: A Review

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Abstract: *Vigna umbellata* (Thunb.) Ohwi and Ohashi, previously *Phaseolus calcaratus*, is a warm-season legume, commonly called as rice bean and it is a mixed crop with maize, sorghum and cowpea. In this paper proximate composition of rice bean flour and its functional properties and effect of soaking on proximate composition, anti-nutritional factors, functional properties, cooking quality and PCMP number (protein phytate, calcium, magnesium and pectin content of the pulses) are reviewed.

Keywords: Rice bean, soaking, phytic acids, polyphenols, legume flours

1. Introduction

*Vigna umbellata* (Thunb.) Ohwi and Ohashi, previously *Phaseolus calcaratus*, is a warm-season legume with yellow and sm all ed icale. It is co mmonly calle d rice bean or ricebean. It is re garded as a m inor crop in agriculture and is of ten g rown as an intercrop or mixed crop with m aize (*Zea mays*), s orghum (*Sorghum bicolor*) or c owpea (*V. unguiculata*), as well as a s o leg crop in the uplands, o n a very l imited area. Li ke t he ot her Asi atic rice bean species, rice bean is a fairly short-lived warm-season annual. Rice bean grows well on a range of soils. It estab lishes itself e arly in the year. The raw protein content of rice bean is lower than that of most pulses. Gopinathan et al. (1987) noted that the protein content of related wild species (e.g. *Vigna minima*) tends to be higher than of cultivated lines, so there may be potential to be bred for improved protein content. However, the amount of calcium and magnesium in the pulses is reported by several authors to be well balanced for human consumption (Chandel et al. 1978; Mohan and Janardhan 1994; Carvalho and Vieira 1996). As in other pulses, an important problem is that rice bean contains various anti-nutrients, notably phytic acid or phytate, polyphenols and tannins that retard the growth of microbes and the digestive system. Rice bean is m ost of ten served as a dhal either soaked overnight and boiled with a few spices or cooked in a pressure cooker. Apart from various recipes for dhal soup and sauces, pulses are also used in a numb er of other ways such as in the form of pickles, soups, stews, and so on. The rice bean varieties having a dark color seed coat tend to have a higher concentration of polyphenols than those having a light color. Soaking usually forms an integral part of bean processing methods such as soaking, germination, fermentation and roasting. Soaking of rice beans facilitates quicker cooking. This is a particularly true when dry beans are used for canning in commercial production (Nordstrom and Sistrunk, 1977). Soaking media include water, salt (or a
combination of salts), and alkali and the soaking water may or may not be discarded prior to cooking depending on regional preferences. Such practices may influence the nutritional quality of beans. Soaking and cooking of legumes result in significant red uction in n p hytic ac di and t ann in co ntents. Maximum red uction of phytic acid (78.05%) an d tannin (65.81%) was f o r sod ium bicarbonate a nd cooking followed by soaking. These treatments also result in a slight reduction in n u trients suc h as pr otein, m inerals an d t otal sugars. It has been known si nce the t hird century BC that certain ch a nges occ ur in leg umes d uring ex tended storage, es pecially at hi gh tem peratures and h umidity, making t hem di fficult t o co ok. T h e s has d o o k phenomenon is a res ult of se veral hypothe sized changes at the m olecular lev el. Th e p ept id e-act ion-phyt ase theory suggests that during storag e an t reacellular enzy me, phytase, hydrol yzes ph yt in, re s ult ing i n the rel ease of d ivalent cations. O nce co oking begins, m onovalent cations from the pe ctin located in the cell wall e xchange with those d ivalent cations to form insoluble pe ctin, become extremely strong and make long stored legumes difficult to cook. This phenomenon is ex pressed t hrough a t erm call ed “PC MP number” which determines the hardness of the bean. Certain water soluble, nutritionally important minerals and vitamins may al so be lost t o so ak w ater, i f d i scarded, al ong with undesir able com ponents such as fla vore, a utec lice e using oligosaccharides, phytates and polyphenols. Kadam et al. (1981) reported that soaking of horse gram in a salt a solut ion of 1.5% NaHCO3, 0.5% Na2SO3 and 0.75% citric acid for 12h caused reduction in cooking time from 145 m i n to 27 mi n. They also observed 69 to 73% improvement in protein digestibility and 35% less p olyphenols in co oked ho rse meat. They als o observed that fat content of t he beans ranged between 0.44g and 0.56g per 100g of rice bean. Saikia et al. (1999) found 0.46-0.52% crude fat from rice bean cultivars appears to be lower th an of most o ther pu lses, al th ough th ere is considerable vari ation in t he fi gures presen ted i n the literature.

### 2. Proximate Composition of Rice Bean Flour

The raw protein content of rice bean cultivars appears to be lower than that of most other pulses, although there is considerable variation in the figures presented in the literature.

<table>
<thead>
<tr>
<th>Author Percentage</th>
<th>17.5 - 23.1</th>
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<tbody>
<tr>
<td>Mohan and Janardhanan (1994)</td>
<td>21.9 - 26.1</td>
</tr>
<tr>
<td>Saikia et al. (1999)</td>
<td>16.9 - 18.0</td>
</tr>
<tr>
<td>Rodriguez and Mendoza (1991)</td>
<td>17.3 - 21.4</td>
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<tr>
<td>Saharan et al. (2002)</td>
<td>18.2 ± 0.2</td>
</tr>
<tr>
<td>Duke (1981)</td>
<td>20.9</td>
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<td>FAO (1982)</td>
<td>18.5</td>
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<tr>
<td>Chandel et al. (1978) 14.0-24.0</td>
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<tr>
<td>Kaur and Kapoor (1992)</td>
<td>17.2 – 18.5</td>
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<tr>
<td><strong>Overall range</strong></td>
<td><strong>14.0-26.</strong></td>
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Duke (1981) gave the following figures for mineral content per 100 g of rice bean: 200 mg Ca, 390 mg P, and 10.9 mg Fe. Analyses of the rice beans revealed a ash content of 4.03%. M alhotta et al. (1988) re ported that carbohydrate content of the beans ranges from 58.15-71.99%. Kaur an d Kapoor (1992) re ported that to tal soluble sugars, non-reducing sugars, starch and total available carbohydrates of five hi gh yielding ri ce bean var ieties varied from 5.0g to 5.6g, 4.4g to 8.3g, 5.2g to 60.1g/100g, respectively. 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 non-reducing sugars. The mineral content of 5 di fferent varieties of rice bean and the concentrations of calcium, phosphorus and iron of rice bean varieties varied from 287mg to 327mg, 234mg to 249mg and 6.3mg to 7.7mg per 100g respectively. In rice bean the extractability of calcium was the highest (ab out 88%) and d phosphorus was the lowest (33%). The concentrations of the other minerals were comparable in all the legumes studied. They als o reported that fat content of t he bean ranged between 0.44g and 0.56g per 100g of rice bean. Saikia et al. (1999) found 0.46-0.52% crude fat in rice bean.

### 3. Effect of soaking on proximate composition of legume flours

Egbe and Akinfele (1990) reported that soaking in crude protein content of lima beans reduced due to leaching of water soluble nut rients into t he soaking water. Rehman et al. (2001) reported th at soaking significantly reduced the total sugars and starch content of kidney beans. Mubarak (2005) reported decrease in fat and ash during soaking treatment of mung bean might be attributed due to leaching or t heir diffusion into the soaking water. Magadi (2007) reported a significant increase in moisture content during soaking and cooking which might be attributed to the leaching of soluble proteins and minerals.

#### 3.1 Antinutritional factors

a) **Phytic acid**

Kaur and Kapoor (1992) found between 1875 and 2270 mg phytic acid in their analysis on five high yielding rice bean varieties. 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%. It is known to be involved in undesirable processes including t hose leading to hard cook phenomenon. This adverse attribute increases cooking time and is important to p eople in developing countries where energy sources including fuel wood are becoming increasingly scarce. Saikia et al. (1999) found from 1998 to 2170 mg phytic acid/100g uncooked rice bean, but substantial reduction after pres sue coo king or t boiling. Saharan et al. (2002) measured 2018 ± 5.9 mg/100g. Rice bean has a fairly high content of phytic acid and its content among cultivars varied significantly. Further reported that the high content of phytate is of nutritional significance as not only is the phytate phosphorus unavailable to the human, but it also lowers the a viability of other ess ential minerals.
b) Polyphenols

Mossely and Griffiths (1979) reported that tannins are responsible for affecting the digestibility of dietary protein and, to a lesser extent, that of available carbohydrate and lipid. He further revealed that tannin ins form complexes with proteins, carbohydrates and other polymers in food as well as with certain metal ions such as iron under suitable conditions and a pH appropriate for the seed coat. Desphande and Cheryan (1982) reported that polyphenols in legumes and cereals are regarded as an intrinsic factor, due mainly to the effects of tannins, which reduce protein digestibility and the inhibitory effect of these compounds on the activities of digestive enzymes such as trypsin, lipase and amylase. This results in the digestibility of the pea protein being reduced compared with light-colored legs such as white bean, and also results in significant losses of some researchers during bean soaking. In contrast, research shows that a sigificant reduction in total phenolic content occurs during a process that combines Soaking and cooking. Nergiz and Gok goc (2007) reported a 57-58% reduction in phytic acid after cooking beans that had been soaked 12 hr prior to cooking. Boateng et al. (2008) also observed that soaking decreased the total phenolic content of the seed coat. This may be due to the presence of tannins, which reduce protein digestibility and have an inhibitory effect on the activities of digestive enzymes such as trypsin, lipase and amylase. This results in the digestibility of the pea protein being reduced compared with light-colored legumes such as white bean and pinto beans. However, higher flavonoid levels were observed in dark-colored legumes such as red kidney beans. Other researchers have reported that soaking and cooking of legumes resulted in significant reduction in phytic acid and tannin content. M. amylum red uction of T. pratensis acidi d (78.05%) was found to be significant, compared with light-colored legumes such as white kidney beans and white grams. He further reported that soaking and cooking of legumes resulted in significant reduction in phytic acid and tannin content. M. amylum reduction of T. pratensis acidi d (78.05%) was found to be significant, compared with light-colored legumes such as white kidney beans and white grams. These treatments also resulted in a slight reduction in nutrients such as protein, minerals and total sugars.

3.2 Effect of Soaking on Phytic Acid and Polyphenolic Content of Legume Flours

Sathe and Salunkhe (1981) observed a marked decrease in the soluble polyphenol content of rice bean in the soaking period. Sin et al. (1983) reported that soaking reduced the polyphenolic content of rice bean. The decrease was more conspicuous at pH 2.0, 3.0, and 4.0, whereas nitrogen solubility, foaming and emulsification properties were decreased significantly. However, gelation remained more or less constant. The nitrogen solubility was found to be 82.1% in the defatted kabuli chickpea which is milled and passed through 72 mesh sieve. Sanjeeva et al. (2008) revealed that dark-colored legumes such as red kidney beans have a higher concentration of polyphenols than the light-colored legumes such as white kidney beans and white grams. They also observed cowpea bicarbonate soaking followed by cooking. These treatments also resulted in a slight reduction in nutrients such as protein, minerals and total sugars.

3.3 Effect of Soaking on Functional Properties of Legume Flours

Hsu et al. (1982) found that the lowest solubility of pea flour, lentils and faba beans were at pH 4.5-5.0. On the other hand, the polyphenolic content started to increase at pH 5 and reached its maximum value at pH 12 (88%). Bencini and Carcea (1986) studied the functional properties of drum and ed c hick pea which is soaked in NaHCO3 medium milled and passed through 60 mesh sieve reported a bulk density of 0.61g/ml, oil absorption capacity of 1.21g, foam volume of 98% and foam stability less than 11ml after 120 min. The least ge lation concentration of 14% showed that there is no remarkable effect of soaking in NaHCO3 medium. Pawar and Ingle (1988) studied the functional properties of beans which were soaked in salt solution for 3, 6, 9 and 12 hr and observed that water and oil absorption capacity of flour protein were significantly increased. However, gelation remained more or less constant. The nitrogen solubility was 82.1% in the defatted kabuli chickpea which is milled and passed through 72 mesh sieve. Sanjeeva et al. (2008) revealed that dark-colored legumes such as red kidney beans have a higher concentration of polyphenols than the light-colored legumes such as white kidney beans and white grams. They also observed cowpea bicarbonate soaking followed by cooking. These treatments also resulted in a slight reduction in nutrients such as protein, minerals and total sugars.

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reported that red kidney bean when soaked dried and passed through Hammer mill passes’ water absorption capacity of 2.25 g per gram of sample.

3.4 Effect of soaking on cooking quality and PCMP number of legume flours:

Rockland and Metzler (1967) soaked Lima and other beans in mix ed salt solution of 1.5% NaHCO₃, 0.5% Na₂CO₃, 2.5% NaCl and 1% so dium polyphosphate and observed significant effect of this soak solution in reduc ing the cooking time. The effect of presoaking of legume seeds in the soak solution of chemicals in reducing the cooking time of peas has been reported. Muller (1967) found that the main factor affecting the cooking quality of seeds of several pea and bean varieties was found to be phytin, Ca, Mg and free pectin. Other factors probably involved were the thickness of the seed coat, palisade layer and the contents of lignin and alpha-cellulose in the seed coat. Matschke (1978) developed a process for the production of quick cooking alpha-cellulose in the seed coats. Cell contents had no significant effect of this soak solution in reducing the cooking time of 12 hr or in salt solution containing NaHCO₃, Na₂CO₃, citric acid pH 7.0 ± 0.05 for 3, 6, 9 and 12 hr and cooked traditionally. The cooking time and protein contents of the peas were found drastically decreased, on soaking in salt solution, from 22 to 5 min (77.27% and 1.32% respectively). Vimala and Pushp amma (1987) reported the cooking time (120±125%) and egg white dispersion(10±12%) of rice bean we re comparable, more or less, to the report ed value of black gram. In their study they found that at water absorption and per cent solid dispersion were key aspects of cooking quality because the higher the values for these parameters the better is the liking for the cooked pulse. Paredes López et al. (1989) Cooking time and seed hardness were increased by growing beans in a location with soils rich in Ca and Mg and higher a verage annual temperature (15–24°C), compared to a location with lower temperature (11–18°C) and soils poor in Mg and P. Kilmer et al. (1994) observed insolubilisation of the pectic substance due to the activation of phytases, phytate degradation during storage, water penetration a nd eventual cross linking of pectins by formation of Ca and Mg pectinates, render the cells resistant to heat penetration a nd destabilise the ability to benefit from the better is the liking for the cooked pulse. Ockenden et al. (1997) reported losses of phy tate in beans is faster at high tem perature and relative humidity dress during storage, conditions t hat enhances bean softening. The water uptake was monitored by soaking 16 g of beans in 100 ml of distilled water at 25°C until a complete soaking was achieved. Neelam khetarpaul et al. (2005) found that the cooking time of untreated soy dhal was 162 min; it reduced significantly by 58–98% when soaked in 0.5, 0.75 and 1% per cent solutions of sodium bicarbonate and soy dhan. They used chemicals for reducing the cooking time of split red gram (Cajanus cajan). So dium carbo nate, sodium bicarbonate, trisodium phosphate and ammonium bicarbonate either alone or in combination were either added to cooking water (0.5–1%) or (b) coated on to dhal and dried or (c) the dhal was soaked in 0.5% so dium hy droxide solutions for 1 hr, drained and washed off the soaked dhal prior to cooking. Combination of trisodium phosphate and ammonium bicarbonate or sodium carbonate and sodium bicarbonate re duced cooking time by 50%. Treat ment (b) was more effective than (a); treatment (c) was not preferred as it led to a bitter taste. Rizley and Sistrunk (1979) observed that peas when soaked in p olyphosphate solution gave a lighter col our, wh ereas soaking in b i carbonate solution gave a less desirable colour but a softer texture and better flavor. They further observed that longer soaking time resulted in greater discoloration. Shinde and Shiralkar (1980) used ammonium carbonate, sodium nitrate, ammounium phosphate, sodium dihydrogen p hate, EDTA, sodium bicarbonate, sodium chlorite, EDTA + sodium bicarbonate at 0.5% w/v to reduce the cooking time of dry beans of rajmah (Phaseolus vulgaris). Of these chem icals only sodium bi carbonate and d E T A al on e or in combination reduced the cooking time from 10 to 3 min. Ka dam et al. (1981) reported that soaking of horse gram in a solution of 1.5% NaHCO₃, 0.5% Na₂CO₃ and 0.75% citric acid for 12 hr was found to be effective in reducing cooking time from 147 to 27 min. They also observed 67% reduction in cooking time of moth bean on soaking in salt solution for 12 hr. Silva et al. (1981) fou nd that a salt co mbination of soaking solution was most effective in pre mo toring b eans so toff ening during cooking compared to no soaking or a distilled water soak to black beans (Phaseolus vulgaris). Narayana (1981) determined cooking characteristics su ch as hydration, dispersion of solids and cooking time of winged bean dhal. He observed that salts such as ammonium carbonate (0.5%) with either sodium carbonate or bi carbonate (0.5%) reduced the cooking time n early 50% and direct addition of these chemicals to the cooking water imparted an alkaline taste and undesirable color. However, coating of the dhal with the chemicals or presoaking in solution of these salts eliminated these disadvantages. Pawar (1986) ob served that water uptake and leaching losses of solids were increase d after soaking of blanched moth beans in either distilled water for 12 hr or in salt solution containing NaHCO₃, Na₂CO₃ and citric acid pH 7.0 ± 0.05 for 3, 6, 9 and 12 hr and cooked traditionally. The cooking time and sol y phenols c ontent were found drastically decreased, on soaking in salt solution, from 22 to 5 min (77.27% and 1.32% respectively).
and 82°C for 3 h in 0.07% NaHCO₃ solution, and followed by precooking at 110°C for 10 min in a hot-air oven. Dehydrated lentils processed by Soaking at 22°C for 2 h and 82°C for 20 min in 0.07% NaHCO₃ solution, and followed by precooking at 106°C for 10 min in a hot-air oven. Abraham and Tzen (2010) reported that the cooking time of untreated Kalimata seed was 87 ± 3.15 min; soaking the seeds in different media for 12 hr reduced the cooking time considerably. Sodium carbonate solution (2%) was found to be the most suitable soaking medium, particularly followed by roasting the seeds. Soaking and/or roasting did not cause pronounced reduction in nutrient content of the sampl e. Sasikala and Narasimha (2010) reported the hardness values of green gram and horse gram and their effect on soaking. The soa king effects on the texture of whole as well as dehulled split green gram and horse gram were studied using universal texture machine and scanning electron microscopy. The hardness values of raw whole legumes of green gram (67.5–69.9 N) and horse gram (186.5–245 N) decreased to 45.3–57.4 N and 137.8–207.8 N, respectively, after 1 hr soaking.

4. Conclusion

Application of blanching preceded by soaking of rice bean seeds, thus offers the dual adv an tage of saving valuable time, as well as rendering the seeds more acceptable to consumers. Soaking of legumes reduces th eir antinutrients; phytic acid and tannin significantly. These treatments may be used domestically as well as commercially to increase the nutrients' availability from legumes. In addition, soaking blanched seeds prior to roasting the seeds, soaking and/or roasting did not cause reduction in the anti-nutrients; phytic acid and tannin.

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