b) **Polyphenols**

Mosely and Griths (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 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. Desphande and Cheryan (1983) observed that rice bean varieties having a dark color seed coat had a higher concentration of polyphenols than those having a light color. The concentration of tannins in the seed of the legumes thus seems to be a function of the color of the seed coat Salunkhe *et al.* (1982) reported that polyphenols in legumes and cereals are regarded as antinutritional factors, due mainly to the effects of tannins, which reduce protein digestibility and the inhibitory effect of these compounds on the activites of digestive enzymes like trypsin, lipase and amylase reduce the digestibility of the protein and carbohydrates and the availability of vitamins and minerals. Malhotra *et al.* (1988) reported polyphenols to be 900 mg/100g in rice bean lower than that in other 'standard crops cowpea, moong, mash'. Kaur and Kapoor (1992) found between 1279 and 1587 mg polyphenols per 100 g in five varieties. Anton *et al.* (2008) reported that total phenolic content was substantially higher in the isolated seed coats of navy and pinto beans than in the whole bean. The high concentration of phenolic components in the bean hull was likely responsible for the increased antioxidant activity of the hull fraction.

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

Sathe and Salunkhe (1981) and observed a marked decrease in tannin equivalent of winged bean during soaking. A successive and significant reduction in polyphenols 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.Deshpande *et al.* (1983) reported that tannin content was reduced by 68.0 to 94.6% using a dehulling process. Data suggests that much of the phenolics in beans are in the hull. Treatments that involve removal of the hull (i.e. dehulling) or manipulation of the hull such as soaking will affect phenolic content. Processes involving heat may also reduce phenolic compounds._Reddy *et al.* (1982) observed that the phytate could be substantially eliminated by Soaking and cooking. The present decrease in phytic acid content in soaked rice bean was comparable to the report of Kataria *et al.* (1989).Kaur and Kapoor (1992) observed that ordinary cooking of unsoaked and soaked seeds decreased the phytic acid content in all the pulses which varied significantly among the rice bean varieties. They also reported cooking of soaked seeds caused a greater reduction in the phytic acid than cooking of unsoaked seeds. El hady and Habiba (2003) observed a 36% reduction in phytic acid and 17% reduction in phenolics and tannin contents in kidney beans after an overnight soaking in water at room temperature. Luthria and Pastor corrales (2005) reported that only 1 and 2% of the phenolic acids were found in the water used for soaking great Northern and black beans, respectively. In their particular experiment, specific phenolic acids were measured. Thus, phenolic compounds other than phenolic acid may account the high losses observed by some researchers during bean soaking. In contrast, research shows that a significant reduction in total phenolic content occurs during a process that combines Soaking and cooking. Nergiz and Gokgoz (2007) reported 57-58% reduction in phytic acid after cooking beans that had been soaked 12hr prior to cooking. Boateng *et al.* (2008) also observed as slight decrease in total phenolic content and tannin levels in soaked kidney and pinto beans. However, higher flavonoids levels were observed in the soaked pinto beans. Nuzhat huma *et al.* (2008) revealed that dark colour legume (red kidney beans) has a high level of phytic acid and tannin compared with light colour (white kidney beans and white grams). He further revealed that soaking and cooking of legumes resulted 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.

3.3 Effect of Soaking on Functional Properties of Legume Flours

Hsu *et al.* (1982) found that the lowest solubility of the protein of yellow pea, lentils and faba bean were at pH 4.5-5.0. On either side of pH 5 the protein solubility started to increase and reached its maximum value at pH 12 (88%). Bencini and Carcea (1986) studied the functional properties of drum dried chick pea which is soaked in $NaHCO_3$ medium milled and passed through 60 mesh sieve reported a bulk density of 0.61g/ml, oil absorption capacity of 1.21g, foaming capacity of <8% and foam stability less than 11ml after 120 min. The least gelation concentration of 14% showed that there is no remarkable effect of soaking in $NaHCO_3$ medium. Pawar and Ingle (1988) studied the functional properties of beans which were soaked in salt solution for 3, 6, 9 and 12hr and observed that water and oil absorption capacity of flour and protein were increased significantly whereas nitrogen solubility, foaming and emulsion properties were decreased significantly. However, gelation remained more or less constant. The nitrogen solubility was. The nitrogen solubility profile of soaked moth bean flours was decreased at all pH and minimum at pH 4.5. The decrease was more conspicuous at pH 2.0, 3.0, 8.0, 9.0, 10.0, 11.0 and 12.0. Giami (1993) studied the effect of soaking on functional properties and found that cowpea when dehulled, blanched and given a soak treatment at 35°C for 10 hr reported an oil absorption capacity of 1.30 g and water absorption capacity of 5.05g. They also observed cow pea when defatted and milled had shown a decrease in 29% of foam volume over 120 min. - Kaur and Singh (2005) found an emulsification activity and emulsification stability of 82.1% in defatted kabuli chickpea which is milled and passed through 72 mesh sieve. Sanjeewa *et al.* (2009) measured the water absorption capacity of chickpea which is soaked in water at room temperature for 40 min and dried to 10-11% moisture content in hot air drier at 50-60°C and milled absorbed 1.20 g per a gram of sample which is low compared to flour of untreated chickpea. Siddiq *et al.* (2009)

reported that red kidney bean when soaked dried and passed through Hammer mill posses' 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 mixed salt solution of 1.5% $NaHCO_3$, 0.5% Na_2CO_3, 2.5% NaCl and 1% sodium polyphosphate and observed significant effect of this soak solution in reducing 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 coats. Cell contents had no detectable effect. Bongirwar and Sreenivasan (1977) developed a process for the production of quick cooking dehydrated peas from dry commercial peas. It involved hydrating the peas by soaking in 0.25% sodium bicarbonate solution for 5hr, pricking the soaked peas for 10 min followed by precooking for 4 min at 1.05 kg/sq gauge pressure and dehydrating the precooked peas in a standard tray drier at 55 to 60^{0}C for 2 to 2.5hr to reduce the moisture content to about 8%. Narsimha and Desikachar (1978) determined the cooking time , water uptake, dispersed solids into cooking water, contents of minerals ,protein and PCMP (a) pectin (Ca + ½ Mg)/phytin or (b) pectin (Ca +1/2Mg) – phytin numbers for ten varieties of pure bred pearled *tur* (*Cajanus cajan*). The hydration of the dispersed solids during progressive cooking (0-80 min) of 4 varieties of polished (15%) and unpolished tur were also determined. They used chemicals for reducing the cooking time of split red gram (*Cajanus cajan*). Sodium carbonate, sodium bicarbonate, trisodium phosphate and ammonium carbonate either alone or in combination were either (a).added to cooking water (0.5-1%) or (b) coated on to dhal and dried or (c) the dhal was soaked in chemical solutions (0.75-1.5g/100g dhal) for 2hr, drained and washed off the soaked dhal prior to cooking. Combination of trisodium phosphate and ammonium carbonate or sodium carbonate and sodium bicarbonate reduced cooking time by 50%. Treatment (b) was more effective than (a), trisodium phosphate was not preferred as it left a bad taste. Rizley and Sistrunk (1979) observed that peas when soaked in pyrophosphate solution gave a lighter colour, whereas soaking in bicarbonate solution gave a less desirable colour but a softer texture and better flavor. They further observed that longer soaking time results in greater discoloration. Shinde and Shiralkar (1980) used ammonium chloride, sodium acetate, ammonium phosphate, sodium dihydrogen phosphate, EDTA, sodium bicarbonate, sodium chloride, EDTA + sodium bicarbonate at 0.5% w/v to reduce the cooking time of dry beans of rajmah (*Phaseolus vulgaris*). Of these chemicals only sodium bicarbonate and EDTA alone or in combination reduced the cooking time from 10 to 3 min. Kadam *et al.* (1981) reported that soaking of horse gram in a solution of 1.5% $NaHCO_3$, 0.5% Na_2CO_3 and 0.75% citric acid for 12hr 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 12hr. Silva *et al.* (1981) found that a salt combination of soaking solution was most effective in promoting bean softening during cooking compared to no soaking or a distilled water soak to black beans (*Phaseolus vulgaris).* Narayana (1981) determined cooking characteristics such 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 bicarbonate (0.5%) reduced the cooking time nearly 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) observed that water uptake and leaching losses of solids were increased after soaking of blanched moth beans in either distilled water for 12hr or in salt solution containing $NaHCO_3$, Na_2CO_3 and citric acid pH 7.0± 0.05 for 3, 6, 9 and 12hr and cooked traditionally. The cooking time and polyphenols content were found drastically decreased, on soaking in salt solution, from 22 to 5 min (77.27% and 1.32 to 0.8% respectively). Vimala and Pushpamma (1987) reported the water absorption (102±125%) and solid dispersion (10±12%) of rice bean were comparable, more or less, to the reported value of black gram. In their study they found that 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 lopez *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 average 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, release of cations and eventual cross linking of pectins by formation of Ca and Mg pectinates, render the cells resistant to water penetration and swelling and to the subsequent failure of adjacent cells to separate upon cooking . Ockenden *et al.* (1997) reported loss of phytate in beans is faster at high temperature and relative humidity during storage, conditions that enhance the hard-to-cook defect. 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 per cent when soaked in 0.5, 0.75 and 1 per cent solutions of sodium carbonate and sodium bicarbonate for 3, 6 and 9hr. The percentage reduction in cooking time was found to be greater when soy dhal was soaked in sodium carbonate solution; however, this adversely affected the colour and flavour. In contrast, soy dhal soaked in sodium bicarbonate was found to be acceptable to the human palate. Zhao and Chang (2008) studied the effect of soaking on cooking quality in peas, lentils and chickpeas which were blanched and soaked in water, then cooked with four different cooking methods and dehydrated in a convection tray dehydrator. Dehydrated yellow and green peas produced by Soaking at 22^{0}C for 9 h and 82^{0}C for 4 h in 0.07% $NaHCO_3$ solution, and followed by precooking at 110^{0}C for 10 min had the best quality with respect to firmness, splitting and butterflying rate. Dehydrated chickpeas produced by Soaking at 22^{0}C for 9 h

and 82^{0}C for 3 h in 0.07% $NaHCO_3$ solution, and followed by precooking at 110C for 10 min had the best quality. Dehydrated lentils produced by Soaking at 22^{0}C for 2 h and 82^{0}C for 20 min in 0.07% $NaHCO_3$ solution, and followed by precooking at 106^{0}C for 10 min had the best quality. Golam and Tzen (2010) reported the cooking time of untreated Kalimatar seed was 187 ± 3.15 min; soaking the seeds in different media for 12hr reduced the cooking time considerably. Sodium carbonate solution (2%) was found as 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 sample. Sasikala and Narasimha (2010) reported the hardness values of green gram and horse gram and their effect on soaking. The soaking 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 1hr soaking.

4. Conclusion

Application of blanching preceded by soaking of rice bean seeds, thus offers the dual advantage of saving valuable fuels by shortening cooking time, as well as rendering the seeds more acceptable to consumers. Soaking of legumes reduce their anti-nutrients; phytic acid and tannin significantly. These treatments may be used domestically as well as commercially to increase the nutrients' availability from legumes to meet the problem of protein and minerals deficiencies. In addition, soaking blanched seeds prior to cooking is more appropriate than cooking for more time from the point of view of fuel consumption and texture. The rice bean treatments examined in this study can thus be used for food preparation. However, these results are obtained on laboratory scale. Further studies on soaking of rice bean using other types of salt solutions on pilot scale are needed to undertake for better utilization of underutilized crops such as rice bean and development of pulse based products with high protein content.

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