DISCUSSION

The various antinutritional substances like total free phenols, tannins, L-DOPA, phytohaemagglutinating activity, phytic acid, HCN and oligosaccharides (raffinose, stachyose and verbascose) have been investigated in different tribal pulses viz., *Abrus precatorius*, *Bauhinia purpurea*, *Canavalia gladiata*, *Dolichos lablab* var. *vulgaris*, *Mucuna monosperma* (Kerala and Tamil Nadu germplasm), *M. pruriens*, *Prosopis chilensis*, *Vigna aconitifolia* and *V. sinensis*.

The content of total free phenols in tribal pulses, *Abrus precatorius*, *Canavalia gladiata*, *Dolichos lablab* var. *vulgaris*, *Prosopis chilensis*, *Vigna aconitifolia* and *V. sinensis* appears to be higher than the different strains of *Vigna umbellata* (Singh *et al.*, 1980) and comparable to that of certain Indian tribal pulses, *Acacia catechu*, *Parkinsonia aculeata* and *Prosopis chilensis* (Rajaram and Janardhanan, 19991c); *Vigna trilobata* (Siddhuraju *et al.*, 1992b), *V. vexillata* (Siddhuraju *et al.*, 1993) and *Acacia leucophloea* (Vijayakumari *et al.*, 1993 b). The other tribal pulses investigated in the present study namely *Bauhinia purpurea* and both the germplasm of *Mucuna monosperma* contain fairly high levels of total free phenols compared with earlier studies in different species of *Bauhinia* (Rajaram and Janardhanan, 1991b; Vijayakumari *et al.*, 1993a). Of all the tribal pulses investigated, *Mucuna pruriens* seems to contain the highest level of total free phenols, which appears to be lower than that of earlier reports in *M. pruriens* (Mary Josephine and Janardhanan, 1992) and *Phaseolus lunatus* (Egbe and Akinyele, 1990).

The data on the tannins contents of different tribal pulses studied reveal that *Abrus precatorius* and *Bauhinia purpurea* contain relatively low levels of tannins when compared with the previous findings in *Abrus precatorius* (Rajaram and Janardhanan, 1992a) and *Bauhinia purpurea* (Rajaram and Janardhanan, 1991b). *Canavalia gladiata*, *Mucuna pruriens* and *Vigna sinensis* contain comparable
amounts of tannins with that of different varieties of *Vigna radiata* (Sharma *et al.*, 1991); *Lathyrus sativus* (Ayyagari *et al.*, 1989) and *Cajanus cajan* (Price *et al.*, 1980). The tannins contents of *Dolichos lablab* var. *vulgaris*, *Prosopis chilensis* and *Vigna aconitifolia* of the present study seem to be more or less equal to that of different strains of *Vigna umbellata* (Hira *et al.*, 1988). Both the germplasm of *Mucuna monosperma* exhibit more or less equal quantity of tannins when compared with the cultivated grain legumes such as *Vigna radiata* (Khan *et al.*, 1979) and *V. unguiculata* (Malhotra *et al.*, 1988) reported earlier.

The non-protein amino acid, L-DOPA (3,4-dihydroxyphenylalanine), is generally present in higher quantity in the genus, *Mucuna*, compared to the other tribal pulses investigated. The levels of L-DOPA detected in the present study in both the germplasm seed samples of *Mucuna monosperma* seem to be higher when compared with an earlier investigation of the same tribal pulse (Arulmozhi and Janardhanan, 1992). The L-DOPA content of *M. pruriens* of the present study is higher than Begur and Silent Valley germplasm and more or less comparable with Lucknow germplasm of an earlier investigation of the same tribal pulse from our Laboratory (Mary Josephine and Janardhanan, 1992). Nonetheless, the L-DOPA content of the different germplasm/species of *Mucuna* of the present study seems to be significantly higher compared to its level in *M. gigantea* (Rajaram and Janardhanan, 1991a). Between the Kerala and Tamil Nadu germplasm of *M. monosperma* the level of L-DOPA seems to be lower in the latter germplasm.

The tribal pulses like *Dolichos lablab* var. *vulgaris*, *Prosopis chilensis*, *Vigna aconitifolia* and *V. sinensis* seem to contain relatively low levels of L-DOPA; whereas *Bauhinia purpurea* and *Canavalia gladiata* appear to contain comparable quantities of L-DOPA compared to earlier reports from our Laboratory (Rajaram and Janardhanan, 1991b; Rajaram and Janardhanan, 1992b). Nonetheless, L-DOPA seems to be conspicuous by its absence in the seeds of *Abrus precatorius*. It is in corroboration with the earlier investigation in *Abrus precatorius* (Rajaram and Janardhanan, 1992a).
Among all the tribal pulses investigated, *Abrus precatorius*, *Dolichos lablab* var. *vulgaris*, both the germplasm of *Mucuna monosperma* and *M. pruriens* are known to exhibit high levels of haemagglutinating activity compared to different varieties of *Phaseolus vulgaris* (Bender and Reaidi, 1982); *Glycine max* (De Muelenaere, 1965) and *Phaseolus lunatus* (Vega and Sotelo, 1986). The lectin activity of *Mucuna pruriens* and *Vigna aconitifolia* seems to be higher in respect of erythrocytes of 'A' and 'B' blood groups compared to 'O' group. The aforesaid pattern of lectin activity is comparable with that of certain varieties of *Phaseolus vulgaris* (De Muelenaere, 1965). The lectins of *Abrus precatorius*, *Bauhinia purpurea*, *Canavalia gladiata*, *Dolichos lablab* var. *vulgaris*, *Mucuna monosperma* (Kerala germplasm) and *Prosopis chilensis* exhibit high levels of agglutination activity specifically with 'B' group compared to the other two blood groups, 'A' and 'O'. While low levels of agglutinating activity is noticed in *Bauhinia purpurea* and *Mucuna pruriens* in respect of the erythrocytes of 'O' group, *Vigna sinensis* lectins show low level of agglutinating activity in respect of the erythrocytes of 'B' group. These trends are comparable with an earlier investigation in the cultivated legumes like *Lens esculenta* and *Pisum sativum* (Bender, 1983).

In the present study fairly high levels of phytic acid are recorded in the tribal pulses, *Bauhinia purpurea*, *Mucuna monosperma* (Kerala germplasm) and *M. pruriens*, which are comparable with that of some of the commonly consumed grain legumes like *Pisum sativum* (Carnovale et al., 1988); *Vigna aconitifolia* (Pawar and Ingle, 1988); *V. mungo* (Kataria et al., 1988) and *V. radiata* (Kataria et al., 1989a). The tribal pulses such as *Abrus precatorius*, *Dolichos lablab* var. *vulgaris*, *Mucuna monosperma* (Tamil Nadu germplasm) and *Prosopis chilensis* are known to contain higher levels of phytic acid than the seeds of *Mucuna utilis* (Ravindran and Ravindran, 1988); *Prosopis glandulosa* (Harden and Zolfaghari, 1988); *Vigna unguiculata* (Akinyele, 1989) and *Phaseolus lunatus* (Egbe and Akinyele, 1990). The contents of phytic acid in *Vigna aconitifolia* and *V. sinensis* appear to be lower when
compared with the other *Vigna* spp. reported earlier (Pawar and Ingle, 1988; Kataria *et al.*, 1988; 1989a). Of all the tribal pulses investigated presently *Vigna sinensis* exhibits the lowest level of phytic acid.

The content of hydrogen cyanide (HCN) in all the tribal pulses studied ranges between 1.01 and 8.52 mg/100g DM. These values are negligible when compared with the lethal level of HCN (35 mg/100g) (Oke, 1969) and other earlier reports in *Phaseolus lunatus* (Montgomery, 1980; Egbe and Akinyele, 1990). *Bauhinia purpurea* contains relatively higher amounts of HCN compared to *Mucuna utilis* (Ravindran and Ravindran, 1988) and *Sphenostylis stenocarpa* (Edem *et al.*, 1990). *Abrus precatorius, Bauhinia purpurea, Mucuna monosperma* (Kerala germplasm), *M.pruriens* and *Vigna aconitifolia* are known to contain higher amounts of HCN compared to bengal gram, kidney beans, peas and red gram(Montgomery, 1980).

The HCN content of *Canavalia gladiata* is found to be lower than a previous finding in the same legume. (Okolie and Ugochukwu, 1989). Jansz and Pieris (1978) have not detected even traces of HCN in another variety of *C.gladiata* grown in Sri Lanka. It is in agreement with the statement that variable amounts of HCN occur in different legume species of the same genera and also between different varieties of the same species (Montgomery, 1964; Vanderborght, 1979). The variabilities may be attributed to differences in some factors of growth environment, for example soil nitrogen content and use of nitrogen fertilizers (Okolie and Ugochukwu, 1989), the latter factor has been shown to increase the cyanide level in *Sorghum almum* during growth (Kriedman, 1964). The contents of HCN in *Dolichos lablab* var. *vulgaris, Mucuna monosperma* (Tamil Nadu germplasm) and *Vigna sinensis* appear to be comparable with that of *Phaseolus vulgaris, Pisum sativum* and *Vigna sinensis* (Montgomery, 1980). The seeds of *Vigna aconitifolia* in the present study seems to contain the highest level of total oligosaccharides followed by *V.sinensis, Canavalia gladiata, Mucuna monosperma* (Kerala and Tamil Nadu germplasm), *Dolichos lablab* var. *vulgaris, Mucuna pruriens, Bauhinia purpurea, Prosopis chilensis* and *Abrus*
precatorius. The contents of oligosaccharides in *Vigna aconitifolia* and *V. sinensis* seem to be higher compared with the values obtained earlier in chickpea, cowpea and lupins (Sosulski *et al.*, 1982) and lower than the values reported earlier in eleven varieties of cowpea (Ologhobo and Fetuga, 1982).

Raffinose is found to be the major oligosaccharide in both the germplasm of *Mucuna monosperma* and *Prosopis chilensis* as has been reported earlier in *Prosopis glandulosa* and *P. velutina* (Becker and Grosjean, 1980).

Stachyose seems to be the principal oligosaccharide in *Abrus precatorius, Bauhinia purpurea, Canavalia gladiata, Dolichos lablab var. vulgaris, Mucuna pruriens* and *Vigna sinensis*. It is in conformity with the earlier reports in chickpea and lentil (Fleming, 1981a); field bean (Salimath and Tharanathan, 1982); cowpea (Onigbinde and Akinyele, 1983) and jackbean, lima bean and sword bean (Revilleza *et al.*, 1990).

On the other hand, verbascose seems to be the predominant galactoside in *Vigna aconitifolia* and it also contains significant amounts of stachyose and raffinose. It is in corroboration with the earlier findings in cowpea, mash, moong and ricebean (Malhotra *et al.*, 1988). Nonetheless, only traces of verbascose are found in *Abrus precatorius, Canavalia gladiata* and *Prosopis chilensis* as has been reported previously in *Canavalia gladiata* (Revilleza *et al.*, 1990).

**COOKING**

Cooking is known to significantly reduce the total free phenols as well as tannins in *Abrus precatorius* (Table 1) and *Bauhinia purpurea* (Table 3). The decrease in phenols content is significant during the first 30 min. and they decline slowly but steadily after 45 min. and 40 min. in *Abrus precatorius* and *Bauhinia purpurea*, respectively. It is in agreement with the earlier study in *Vigna unguiculata* (Laurena *et al.*, 1987). Complete loss of tannins is observed after 30 min. in *Abrus precatorius* and 10 min. in *Canavalia gladiata* (Table 5). The total free phenols content of *C. gladiata* seems to be reduced to 60% at 60 min. cooking time. In an earlier study the effectiveness of cooking treatment in reducing phenols in lima bean
has been demonstrated (Egbe and Akinyele, 1990). Cooking for 90 min. in *Dolichos lablab* var. *vulgaris* (Table 7) and 3h. in both the germplasm of *Mucuna monosperma* (Tables 9 and 11) significantly reduce the contents of tannins (61-69%). It is in consonance with an earlier report in *Canavalia ensiformis* cooked for 60 min. (Babar *et al.*, 1988). The total free phenols content gets reduced to moderate levels (36-40%) for the same duration in the above said three tribal pulses.

In the case of *Mucuna pruriens* (Table 13) the total free phenols slowly get decreased up to 45 min. of cooking, subsequently in 60 min. time, the phenols content appears to increase slightly compared to the raw seeds. The tannins content significantly gets reduced at 75 min. (61%) but subsequently at 90 min. interval the tannins content seems to increase up to 14% compared to the control sample in the aforesaid tribal pulse. The increase of tannins content has been attributed to an uptake of tannins by the beans from the cooking medium, since as cooking time progresses the cooking water is partially absorbed by the beans (Bressani *et al.*, 1982).

In *Prosopis chilensis* 120 min. (Table 15) and *Vigna aconitifolia* 30 min. (Table 17) cooking interval seems to be ineffective in reducing the total free phenols content; whereas in *V. sinensis* (Table 19) significant reduction in content of phenols occurs when subjected to cooking for 60 min. It is in corroboration with earlier reports in cowpea and pigeonpea (Ekfenyong, 1985) and mungbean (Barroga *et al.*, 1985).

Cooking results in loss of polyphenols due to leaching in water (Babar *et al.*, 1988). On the contrary binding of polyphenols with other organic substances or alterations in the chemical structure of polyphenols render them incapable of giving chemical colour reaction (Bressani and Elias, 1979). Loss of tannins may also be due to heat degradation of tannin molecules or formation of water soluble complexes with other macromolecules of the beans. Such water soluble complexes could leach
out into the cooking medium (Kumar et al., 1979; Uzogara et al., 1990) or phenols react with proteins forming poorly extractable protein-phenolic complexes (Kataria et al., 1988).

Pharmacologically active factor, 3,4-dihydroxyphenylalanine (L-DOPA), (Pieris et al., 1980; Jayaweera, 1981) is potentially toxic (Duke, 1981; Afolabi et al., 1985), if large amounts are ingested. Thus the intoxication associated with the overeating of Mucuna beans is probably associated with their L-DOPA content rather than with any other antinutritional factor. The common way of preparing the bean for consumption seems to be cooking after soaking overnight. However, because of the possible toxicity from L-DOPA, overeating should be avoided (Ravindran and Ravindran, 1988).

Significant reduction in content of L-DOPA has been observed in Bauhinia purpurea, Canavalia gladiata, both the germplasm of Mucuna monosperma and Vigna sinensis (Tables, 3,5,9,11 and 19, respectively) when the raw samples are subjected to cooking under different time intervals. On the contrary, the cooking treatment seems to be ineffective in reducing the levels of L-DOPA in Dolichos lablab var. vulgaris, Mucuna pruriens, Prosopis chilensis, and Vigna aconitifolia (Tables 7,13,15 and 17, respectively).

Shankaranarayan (1978) has reported that the tribal people, Kanikkars, in Kerala, South India consume the seeds of Mucuna utilis as food after repeated boiling with water. Significant reduction in content of L-DOPA as a consequence of boiling the seeds of M.utilis for seven times has been demonstrated (Jebadhas, 1980).

In Abrus precatorius, Mucuna monosperma (Kerala germplasm), M. pruriens, Prosopis chilensis, Vigna aconitifolia and V.sinensis (Tables 1,9,13,15, 17 and 19, respectively) the lectin activity has been reduced very significantly under cooking process against all the human blood groups ABO without any specificity. The lectin activity of Canavalia gladiata (Table 5), Dolichos lablab var. vulgaris (Table 7) and Mucuna monosperma (Tamil Nadu germplasm) (Table 11) gets reduced to the maximum level against the human erythrocytes from blood groups 'B' and 'O';
whereas in *Bauhinia purpurea* (Table 3) the reduction has been observed only with respect to the erythrocytes of ‘A’ and ‘B’ blood groups. This observation is in agreement with the earlier reports in different cultivars of *Cicer arietinum* (Bansal *et al.*, 1988); *Lens culinaris* (Batra, 1987) and *Phaseolus vulgaris* (Rea *et al.*, 1985).

Substantial reduction of lectin activity against ‘O’ group in *Bauhinia purpurea* and ‘A’ group in *Canavalia gladiata*, *Dolichos lablab* var. *vulgaris* and *Mucuna monosperma* (Tamil Nadu germplasm) has been noticed under cooking. In general, agglutinating activity of lectin seems to get reduced with increased cooking time. The incomplete destruction of haemagglutinating activity might be due to the presence of high levels of other antinutritional factors which, may interfere with lectins destruction. It is in corroboration with earlier study in *Phaseolus lunatus* (Egbe and Akinyele, 1990).

The site of action of lectins inside the human digestive system is most likely the cells lining the intestinal mucosa, where they interfere with the absorption of nutrients (Liener, 1980). Although all the pulses show haemagglutinating properties, the number of red blood cells which get agglutinated decrease with cooking time. It may be due to decrease in the reactivity with the erythrocyte receptor cells (Egbe and Akinyele, 1990).

Subjected to cooking the phytic acid contents of *Abrus precatorius* (90 min.), *Canavalia gladiata* (60 min.), *Mucuna monosperma* (Tamil Nadu germplasm) (3h.) and *Vigna aconitifolia* (30 min.) (Tables 2,6,12 and 18, respectively) seem to get reduced between 39 and 43%. Similar results have been reported earlier in black gram (Duhan *et al.*, 1989) and cowpea (Akinyele, 1989; Uzogara *et al.*, 1990). Moderate decrease in content of phytic acid seems to occur in *Bauhinia purpurea*, *Mucuna monosperma* (Kerala germplasm), *Prosopis chilensis* and *Vigna sinensis* (Tables 4,10, 16 and 20, respectively) in the present study, as has been reported previously in black gram (Kataria *et al.*, 1988). Insignificant loss in contents of phytic acid in *Dolichos lablab* var. *vulgaris* (Table 8) and *Mucuna pruriens* (Table 14) is in
consonance with the previous reports in mungbean (Kataria et al., 1989a) and soyabean and cowpea (Marfo et al., 1990).

In general, the loss of phytic acid content in all the tribal pulses investigated is positively correlated with the cooking time. The apparent decrease in phytic acid content of the legume seeds during cooking may be partly attributed to the formation of insoluble complexes between phytate and other components (Kumar et al., 1978).

As would be expected the different tribal pulses investigated have shown significant reduction in the levels of hydrogen cyanide when subjected to cooking treatment (45-73%). Nonetheless some of the tribal pulses still retain appreciable levels of residual HCN. The latter finding is in consonance with an earlier report in commonly consumed pulses like Cajanus cajan, Phaseolus aureus and Vigna unguiculata (Okolie and Ugochukwu, 1989). When compared with different time intervals with loss in contents of HCN, maximum loss has been observed between 30 min. and 40 min. interval in Bauhinia purpurea (Table 4).

The loss of HCN content in Canavalia gladiata (54%) (Table 6) is slightly higher than the previous report (49%) in Nigerian C. gladiatus (Okolie and Ugochukwu, 1989). Among all the tribal pulses investigated, maximum loss of HCN content has been observed in Vigna sinensis (73%) (Table 20). It is in conformity with the previous finding in Phaseolus lunatus when subjected to cooking for 160 min. (Egbe and Akinyele, 1990). Cooking is a safe method for the elimination of toxicity in legume seeds because cooking destroys the enzyme linamerase at 72°C (Joachim and Pandittesekere, 1944) but not the glucoside. Montgomery (1980) has reported that most of the liberated HCN is lost by volatilization during cooking and cyanide is rapidly converted to thiocyanates or other compounds.

The seeds of Abrus precatorius, Dolichos lablab var. vulgaris, Mucuna pruriens (Tables 2, 8 and 14, respectively) when subjected to cooking for 90 min. show the reduction in content of raffinose 46%, 53% and 40%, respectively and stachyose 43%,
58% and 60%, respectively. It is in agreement with an earlier report of Jood et al.
(1985) in *Cicer arietinum, Phaseolus mungo* and *P. vulgaris*, where both raffinose and
stachyose get reduced to an extent of 40-56% when subjected to cooking for 60 min.

Significant loss of raffinose content (62-63%) has been observed in *Bauhinia
purpurea* (Table 4) and *Vigna aconitifolia* (Table 18) when cooked for 60 min. and 30
min. respectively, which is in conformity with an earlier finding in *Dolichos lablab*
(62.5%) (Revilleza et al., 1990). On the contrary in *Cajanus cajan, Cicer arietinum, Phaseolus aureus* and *P. mungo* the raffinose level has been shown to increase due to
cooking (Udayasekhara Rao and Belavady, 1978). Among the ten different tribal
pulses investigated in the present study, the reduction of raffinose content is
ineffective in *Canavalia gladiata* (Table 6) and both the germplasm of *Mucuna
monosperma* (Tables 10 and 12). Significant decrease in the level of verbascose has
been noticed in *Bauhinia purpurea, Dolichos lablab var. vulgaris, Vigna aconitifolia*
and *V. sinensis* (Tables 4, 8, 18 and 20, respectively). It is in consonance with the
previous reports in *Lens esculenta* (Iyengar and Kulkarni, 1977) and *Cicer arietinum*
and *Vicia faba* (Jood et al., 1985).

The seeds of *Mucuna monosperma* (Kerala and Tamil Nadu germplasm) when subjected to cooking for 3h. show little reduction in content of verbascose. It is
in corroboration with the previous report of Reddy and Salunkhe (1980) in black
gram.

Decrease in contents of raffinose, stachyose and verbascose due to cooking
has been probably due to heat hydrolysis of the oligosaccharides to simple
disaccharides and monosaccharides or to the formation of other compounds
(Onigbinde and Akinyele, 1983).

**SOAKING**

Soaking in distilled water seems to lower the content of total free phenols
more than 50% in all the tribal pulses investigated in the present study except
in *Abrus precatorius, Canavalia gladiata, Mucuna pruriens* and *Vigna sinensis*
(Tables 21, 25, 33 and 39, respectively). Nonetheless, in certain tribal pulses an increase in content of tannins has been observed during soaking treatments. The increase in content observed may be due to the degradation of high molecular insoluble polymer into small molecular weight soluble polymers that give a colour reaction with the reagent (Satwadhar et al., 1981).

In both distilled water and salt water soaking treatments the maximum decrease in phenol content occurs in the first 1h. period of soaking and prolonging the soaking thereafter is not effective in reducing the phenols content in Bauhinia purpurea (Tables 23 and 43), Vigna aconitifolia (Tables 37 and 57) and V. sinensis (Tables 39 and 59). On the other hand distilled water soaking reduce the contents of total free phenols to a maximum level when soaked for more than 1h. in Dolichos lablab var. vulgaris (1 1/2h.), Mucuna monosperma (Kerala and Tamil Nadu germplasm) (3h.) and M. pruriens (1 1/2h.) (Tables 27, 29, 31 and 33, respectively). Similarly prolonging the salt water soaking treatment for more than an hour result in reducing the phenols content in Dolichos lablab var. vulgaris (between 1 1/2 and 3h.) (Table 47) and Mucuna monosperma (Tamil Nadu germplasm) (3h.) (Table 51).

Earlier similar trend in reducing the contents of tannins during soaking has been reported by Udayasekhara Rao and Deosthale (1982) in chickpea and pigeonpea; Deshpande and Cheryan (1983) in dry beans; Barroga et al (1985) in mungbean; Laurena et al (1986) in cowpea; Kataria et al (1988) in black gram and Uzogara et al (1990) in cowpea. In general salt water soaking appears to be more effective than distilled water soaking in reducing the levels of polyphenols.

Since the polyphenolic compounds are water soluble in nature (Kumar et al., 1979) and mostly located in seed coat (Singh, 1988), the decrease in content of tannins in tribal pulses during soaking may be attributed to leaching out of the phenol contents into soaking water under the influence of the concentration gradient.

When subjected to soaking both in distilled water and salt water the levels of L-DOPA get reduced significantly in Bauhinia purpurea (Tables 23 and 43), Dolichos lablab var. vulgaris (Tables 27 and 47) and Vigna aconitifolia (Tables 37 and 57);
whereas in *Canavalia gladiata*, *Mucuna monosperma* (Kerala germplasm) and *Vigna sinensis* (Tables 45, 49 and 59, respectively) significant reduction in levels of L-DOPA occurs only in salt water soaking. The seeds of *Mucuna monosperma* (Tamil Nadu germplasm) (Tables 31 and 51) and *Prosopis chilensis* (Table 55) show moderate loss of L-DOPA when soaked in distilled water as well as salt water in the case of the former pulse and only salt water in the case of the latter pulse. Generally, distilled water soaking seems to be less effective in eliminating the content of L-DOPA compared to salt water soaking in all the tribal pulses studied.

Soaking in distilled water reduces the haemagglutinating activity in *Abrus precatorius*, *Bauhinia purpurea* and *Prosopis chilensis* (Tables 21, 23 and 35, respectively) in respect of ‘B’ blood group. Losses range between 52 and 69%. It is in agreement with earlier findings of Noah et al (1980) in *Phaseolus vulgaris*; Bender and Reaidi (1982) in *Pisum sativum* and Batra (1987) in *Lens culinaris*. Kaul and Bajwa (1987) also have reported that soaking eliminates the lectin activity in *Phaseolus mungo*. Distilled water soaking does not seem to be effective in eliminating lectin activity in respect of the erythrocytes of all the blood groups (A, B and O) studied in *Mucuna pruriens* (Table 33) and *Vigna sinensis* (Table 39). These results are in agreement with the previous reports in *Phaseolus vulgaris* (Thompson et al., 1983) and LH-82-6 strain of *Lens culinaris* (Batra, 1987).

Salt water soaking treatment seems to be less effective in destroying the agglutinating activity of *Mucuna pruriens* (Table 53) and *Vigna aconitifolia* (Table 57) compared to the other tribal pulses investigated. Salt water soaking is more or less equally effective in reducing the activity of lectins in respect of erythrocytes of ‘B’ and ‘O’ blood groups than the ‘A’ blood group in *Canavalia gladiata*, *Dolichos lablab* var. *vulgaris*, *Mucuna monosperma* (Tamil Nadu germplasm) and *Vigna sinensis* (Tables 45, 47, 51 and 59, respectively). However, salt water soaking is found to be more effective in reducing the activity of lectins than the distilled water soaking in all the tribal pulses studied.
Soaking in distilled water reduces the phytic acid content of different tribal pulses studied which ranges from 14 to 46%. Minimum loss of phytic acid seems to occur in *Prosopis chilensis* (Table 36) during soaking. It is in agreement with the earlier study in *Phaseolus aureus* (Sattar et al., 1989). During soaking in distilled water the seeds of *Bauhinia purpurea*, *Dolichos lablab* var. *vulgaris*, *Mucuna monosperma* (Kerala and Tamil Nadu germplasm), *M.pruriens* and *Vigna sinensis* (Tables 24, 28, 30, 32, 34 and 40, respectively), moderate reduction in levels (27-37%) of phytate content occurs, which is in conformity with the earlier reports in *Vigna unguiculata* (Ologhobo and Fetuga, 1984a) and *V.mungo* (Duhan et al., 1989).

The observation that more than 40% reduction in content of phytic acid occurs during distilled water soaking in *Abrus precatorius*, *Canavalia gladiata* and *Vigna aconitifolia* (Tables 22, 26 and 38, respectively) is in consonance with the previous finding of Khokhar and Chauhan (1986) in *Vigna aconitifolia*. Further, the fact that with increasing periods of soaking there is a corresponding reduction in the contents of phytate has been noticed in distilled water as well as salt water treatments. Earlier similar trend has been observed in various other legumes (Kataria et al., 1988; 1989a; Duhan et al., 1989; Sattar et al., 1989). In all the pulses studied except *Mucuna monosperma* (Tamil Nadu germplasm) (Tables 32 and 52) the distilled water soaking seems to be more effective than salt water soaking in lowering the contents of phytic acid. This confirms the results of Khan et al. (1986) in wheat and Khan et al. (1988) in white variety of *Cicer arietinum*, who have reported that the loss of phytic acid is less in the presence of sodium bicarbonate. In *Mucuna monosperma* (Tamil Nadu germplasm) (Tables 32 and 52) both distilled water and salt water soakings effect reduction of phytic acid in equal amounts.

Soaking induced reduction in phytate content in legumes may be attributed to the activity of phytase and diffusion. An increase in the phytase activity coinciding with decrease in the level of phytate as a result of soaking in fababean has been recorded (Eskin and Wiebe, 1983). Both the enzymatic hydrolysis of phytate followed by diffusion has already been attributed for the removal of phytate in dry
beans (Chang et al., 1977). However, in the case of pulses all the phytin has been associated with P, K, Ca and Mg. In case, phytin is associated with P, it seems to be water soluble and hence its removal by diffusion seems to be easy (Lolas and Markakis, 1975), on the other hand if phytin is associated with K, Ca or Mg, the removal by diffusion is rather difficult.

There seems to be a positive correlation between the reduction in content of HCN and duration of soaking period in all the tribal pulses investigated. Significant reduction in content of HCN occurs in *Dolichos lablab* var. *vulgaris* (Tables 28 and 48) and *Prosopis chilensis* (Tables 36 and 56) when subjected to both distilled water as well as salt water soaking. Of all the tribal pulses investigated, the reduction of HCN content seems to be insignificant in *Bauhinia purpurea* (Table 24) and *Mucuna monosperma* (Kerala germplasm) (Table 50) when soaked in distilled water and salt water, respectively. Soaking in distilled water (ranging between 23 and 43%) appears to be less effective in lowering the HCN content compared to salt water soaking (ranging between 32 and 52%) in *Abrus precatorius*, *Bauhinia purpurea*, *Canavalia gladiata*, *Mucuna monosperma* (Kerala germplasm), *M.pruriens*, *Vigna aconitifolia* and *V. sinensis*.

Endogenous and autolytic enzymes are inactive (Panasuik and Bills, 1984) but are activated by hydrolysis. The HCN produced during hydrolysis is water soluble and this accounts for the decrease in cyanide content during soaking. In soaked seeds of *Cajanus cajan*, *Canavalia gladiatus*, *Phaseolus aureus* and *Vigna unguiculata* for 24h. there seem to be appreciable reduction in the content of HCN in cotyledon which may well account for the HCN detected in the soaked water (Okolie and Ugochukwu, 1989). Similar results have been obtained in sorghum (Obizoba and Atii, 1991).

Soaking in distilled water does not result in significant reduction in the content of raffinose regardless of the time in *Abrus precatorius*, *Dolichos lablab* var. *vulgaris*, *Mucuna monosperma* (Kerala and Tamil Nadu germplasm) and *Prosopis chilensis* (Tables 22, 28, 30, 32 and 36, respectively). It is in consonance with an
earlier study in *Dolichos lablab* (Revilleza et al., 1990). The reduction of stachyose during distilled water soaking in *Abrus precatorius, Bauhinia purpurea, Dolichos lablab* var. *vulgaris, Mucuna pruriens, Prosopis chilensis, Vigna aconitifolia* and *V. sinensis* (Tables 22, 24, 28, 34, 36, 38 and 40, respectively) (ranging between 9 and 18%) seem to be more or less equal to that of earlier investigations in *Phaseolus vulgaris* (Silva and Braga, 1982; Jood et al., 1985) and *Cajanus cajan* (Jood et al., 1985).

Upadhyay and Garcia (1982) have demonstrated that the solubility of the individual oligosaccharide and the diffusion rate as two factors that could influence the sugar losses during soaking. Iyengar and Kulkarni (1971) earlier have suggested that the loss of oligosaccharides is mainly due to their being leached out or solubilisation in the surrounding medium rather than due to hydrolysis or any breakdown. The diffusion rate in turn would depend on the thickness and permeability of the seed coat. Except *Bauhinia purpurea* and *Vigna aconitifolia* all the tribal pulses investigated have a thick and hard seed coat which might prevent significant diffusion of oligosaccharides. The same trend has been observed in *Dolichos lablab* (Revilleza et al., 1990).

One interesting observation of the present study is that during soaking in both distilled water and salt water, maximum reduction has been observed in the levels of verbascose followed either by stachyose or raffinose contents except the species/germplasm of the genus, *Mucuna*. This trend is attributed to the fact that galactosidase first attacks verbascose. This finding is in agreement with the earlier reports in *Phaseolus mungo, P. vulgaris* and *Vicia faba* (Jood et al, 1985).

In general, all the tribal pulses investigated, after being soaked, the raffinose, stachyose and verbascose contents get decreased proportionately with the time of soaking, the reduction being significantly higher in the case of seeds soaked in salt solution compared to those soaked in distilled water.

Soaking an integral part of traditional methods of processing, saves energy costs by shortening cooking time and offers an additional advantage of rendering the
grains nutritionally superior by removing certain antinutritional factors. Soaking in distilled water may be preferable to that of sodium bicarbonate solution because of susceptibility of some vitamins of the B complex group, particularly thiamin and riboflavin, which are known to be destroyed slowly in alkaline medium at room temperature (Swaminathan, 1974).

**DRIY HEAT TREATMENT**

Significant reduction of total free phenols (ranging from 58 to 84%) has been observed in all the tribal pulses studied except *Canavalia gladiata* (Table 65) and *Mucuna pruriens* (Table 73) when subjected to dry heat treatment. This treatment results in significant reduction of tannins in *Canavalia gladiata, Mucuna monosperma* (Kerala germplasm), *M. pruriens, Prosopis chilensis, Vigna aconitifolia* and *V.sinensis* (Tables 65, 69, 73, 75, 77 and 79, respectively). These results coincide with a previous work carried out by Laurena et al (1987), who have reported that roasting lowered polyphenol contents very significantly in *Vigna unguiculata*. The total free phenols and tannins in *Abrus precatorius* (Table 61) and *Bauhinia purpurea* (Table 63) seem to get reduced more than half their original contents in raw seeds. The application of dry heat does not seem to be effective in reducing tannins in *Dolichos lablab* var. *vulgaris* (Table 67) and *Mucuna monosperma* (Tamil Nadu germplasm) (Table 71).

Earlier investigations indicate that roasting/dry heat treatment reduce polyphenols in *Canavalia ensiformis* (Babar et al., 1988) and *Vigna radiata* (Barroga et al., 1985). Reduction in levels of polyphenols may be attributed to the heat degradation of tannin molecules (Uzogara et al., 1990) or polyphenols getting changed chemically (Barroga et al., 1985). Inactivating the polyphenols in situ by thermal means may also have drastic effects on the other constituents of the seeds like carbohydrates (Hoseney, 1984); lipids (Nawar, 1984) and the overall effect in lowering nutritional quality.

Dry heat treatment has significantly (52-80%) lowered L-DOPA in *Bauhinia purpurea, Canavalia gladiata, Dolichos lablab* var. *vulgaris, Vigna aconitifolia* and
V. sinensis (Tables 63, 65, 67, 77 and 79, respectively). On the contrary, in both the germplasm of Mucuna monosperma, M. pruriens and Prosopis chilensis (Tables 69, 71, 73 and 75, respectively) dry heat treatment appears to be ineffective in reducing the contents of L-DOPA.

The possible reduction of L-DOPA content may be attributed to its racemization under roasting. Studies of Hayase et al. (1975a) have shown that amino acid residues in proteins and in synthetic peptides can racemize under roasting conditions.

In all the different tribal pulses dry heat treatment results in complete loss of lectin activity except in Canavalia gladiata (Table 65) and Mucuna monosperma (Kerala germplasm) (Table 69) which exhibit a low lectin activity. The presence of residual lectin activity after dry heat treatment is in consonance with the earlier studies in Lens culinaris (Batra, 1987) and Phaseolus vulgaris (Almeida et al., 1991). Complete loss in lectin activity has been reported earlier in Phaseolus spp. (Liener, 1979); P. mungo (Kaul and Bajwa, 1987) and different cultivars of Cicer arietinum (Bansal et al., 1988). A survey of the literature reveals that the lectins in Glycine max and Phaseolus vulgaris (De Muelenaere, 1964) and Psophocarpus tetragonolobus (Tan et al., 1983) are known to be resistant to dry heating.

The elimination/reduction of lectins activity may be due to haemagglutinin (proteins) breakdown into their subunits or undergo some other unknown conformational changes in their native structures which might be required for their haemagglutinating activity (Batra, 1987).

Invariably in all the tribal pulses studied the reduction of phytic acid has been directly related to the duration of time intervals of roasting or dry heat treatment. When compared with all the other tribal pulses investigated, Prosopis chilensis (Table 76) seems to have very little effect on reduction in content of phytate. The ineffectiveness of dry heat treatment in reducing the contents of phytate in cowpea and soyabean has been reported earlier (Marfo et al., 1990). Moderate levels of reduction in contents of phytate in Mucuna monosperma (Tamil Nadu germplasm)
(Table 72) and *M. pruriens* (Table 74) is observed. Similar observation has been made earlier in the brown variety of bengal gram (Khan *et al.*, 1988). When subjected to roasting at 120°C for different time intervals the seeds of *Abras precatorius*, *Bauhinia purpurea*, *Canavalia gladiata*, *Dolichos lablab* var. *vulgaris*, *Mucuna monosperma* (Kerala germplasm), *Vigna aconitifolia* and *V. sinensis* (Tables 62, 64, 66, 68, 70, 72, 74, 78 and 80, respectively) exhibit the loss of phytate ranging from 40 to 48%.

The HCN content of all the investigated tribal pulses get reduced under dry heat treatment significantly. However, none of the tribal pulses seem to be toxic since their levels of HCN content is far below the lethal level of 35 mg/100g (Oke, 1969). Significant reduction in contents of HCN has been observed in *Abras precatorius*, *Bauhinia purpurea*, *Canavalia gladiata*, *Dolichos lablab* var. *vulgaris*, *Mucuna monosperma* (both the germplasm), *M. pruriens*, *Vigna aconitifolia* and *V. sinensis* (Tables 62, 64, 66, 68, 70, 72, 74, 78 and 80, respectively). While *Prosopis chilensis* (Table 76) exhibits the lowest response to dry heat treatment resulting in moderate decrease in the content of HCN, *Vigna sinensis* shows the highest response resulting in the maximum reduction in content of HCN of all the tribal pulses investigated.

Of the three oligosaccharides studied dry heat treatment causes the maximum reduction of stachyose in all the tribal pulses, except in *Abras precatorius* (Table 62), *Bauhinia purpurea* (Table 64) and *Dolichos lablab* var. *vulgaris*, (Table 68), (ranging between 29 and 60%). It reduces raffinose content to the extent of 29% and 28% in *Abras precatorius* (Table 62) and *Mucuna pruriens* (Table 74), respectively. The decrease in raffinose content ranges from 30 to 35% in *Bauhinia purpurea*, *Canavalia gladiata* and *Dolichos lablab* var. *vulgaris* (Tables 64, 66 and 68, respectively). Losses of more than 40% raffinose content has been observed in *Vigna aconitifolia* (Table 78) and *V. sinensis* (Table 80). The reduction of raffinose content ranged from 20 to 27% in *Mucuna monosperma* (Kerala and Tamil Nadu germplasm) and *Prosopis chilensis* (Tables 70, 72 and 76, respectively).
In *Abrus precatorius* (Table 62), *Canavalia gladiata* (Table 66) and *Prosopis chilensis* (Table 76), the verbascose content has been completely eliminated since the raw seeds are known to contain only traces of verbascose. The seeds of *Bauhinia purpurea*, both the germplasm of *Mucuna monosperma* and *M.pruriens* (Tables 64, 70, 72 and 74, respectively) exhibit 31-38% reduction in content of verbascose. Dry heat treatment seems to be more effective in reducing the levels of all the three sugars (oligosaccharides) in *Vigna aconitifolia* (Table 78) and *V.sinensis* (Table 80) compared to the other tribal pulses studied. Dry roasting at high temperatures is known to completely eliminate/remove the oligosaccharides in *Dolichos lablab* (Revilleza *et al.*, 1990).

The reduction of oligosaccharides is probably because of non-enzymatic browning reaction, oxidation of sugars or pyrolysis (Revilleza *et al.*, 1990).

Generally excessive heat treatment causes proteins to undergo many complex reactions which decrease their digestibility (Laurena *et al.*, 1987). Therefore, when severely applied dry heat processes like roasting can lead to the formation of cross links between polypeptide chains via amidation (Asquith *et al.*, 1974; Hayase *et al.*, 1975b), transamidation (Bjarnason and Carpenter, 1970) and these cross linkages within the protein may prevent or hinder its digestion. Apparently the use of wet heat is preferable compared to dry heat treatment while considering the overall nutritional quality.

**AUTOCLAVING**

Autoclaving at 15 psi pressure and 121°C seems to significantly destroy total free phenols in all the tribal pulses investigated (56-92%) except in *Mucuna pruriens* (Table 93) and *Prosopis chilensis* (Table 95). The loss of tannins appears to be insignificant in *Bauhinia purpurea* (Table 83). In *Abrus precatorius*, *Dolichos lablab* var. *vulgaris* and *Vigna sinensis* (Tables 81, 87 and 99, respectively) the loss of total free phenols as well as tannins occurs to the extent of more than 70% for different
time intervals studied. It is in consonance with the earlier reports in *Canavalia ensiformis* (Babar et al., 1988) and *Vigna unguiculata* (Laurena et al., 1987; Uzogara et al., 1990). In general all the tribal pulses subjected to autoclaving in the present investigation, register the highest loss of total free phenols and tannins compared to raw seeds. This observation is in corroboration with an earlier study in cowpea and pigeonpea (Ekpenyong, 1985). On the contrary, Kataria et al (1988 and 1989a) have reported earlier, insignificant reduction in quantity of polyphenols in black gram and mungbean.

The loss of polyphenols after autoclaving may be due to the interaction of polyphenols with other components of seeds such as protein to form insoluble tannin-protein complexes (Babar et al., 1988) or reduced extractability due to their changed chemical reactivity (Satwadhar et al., 1981).

Loss of L-DOPA content is positively correlated with the duration of autoclaving in all the tribal pulses studied. Significant reduction in content of L-DOPA seems to take place under autoclaving in *Bauhinia purpurea* (30 min.); *Canavalia gladiata* (30 min.); both the germplasm of *Mucuna monosperma* (90 min.); *Vigna aconitifolia* (20 min.) and *V. sinensis* (30 min.) (Tables 83, 85, 89, 91, 97 and 99, respectively). Moderate loss of L-DOPA content seems to occur in *Dolichos lablab* var. vulgaris (Table 87), *Mucuna pruriens* (Table 93) and *Prosopis chilensis* (Table 95) after autoclaving for 45 min.

Autoclaving seems to eliminate the haemagglutinating activity completely in *Bauhinia purpurea, Dolichos lablab* var. vulgaris, *Mucuna monosperma* (Kerala and Tamil Nadu germplasm), *Vigna aconitifolia* and *V. sinensis* (Tables 83, 87, 89, 91, 97 and 99, respectively) autoclaved for 30 min., 45 min., 90 min., 20 min. and 30 min., respectively, in respect of erythrocytes of all the three blood groups studied. In *Abrus precatorius* (Table 81) significant reduction (ranging from 94 to 98%) of haemagglutinating activity occurs for all the blood groups (A, B and O) as in the case of an earlier report in lentil (Batra, 1987). Selective loss of haemagglutinating activity in respect of erythrocytes of the three blood groups ‘A’, ‘B’ and ‘O’ seems to
take place in *Canavalia gladiata* (Table 85), *Mucuna pruriens* (Table 93) and *Prosopis chilensis* (Table 95).

Generally, autoclaving seems to be the effective method in lowering/eliminating the haemagglutinating activity in all the legumes. Similar results have been noticed by earlier investigators in different legume seeds, *Glycine max* (De Muelenaere, 1964); *Phaseolus vulgaris* (Kakade and Evans, 1965; Thompson *et al.*, 1983); *Cajanus cajan* (Ochetin and Bogere, 1983); *Psophocarpus tetragonolobus* (Tan *et al.*, 1983; Kadam and Smithard, 1987) and *Lathyrus sativus* (Ayyagari *et al.*, 1989).

Atmospheric cooking appears to be less effective than autoclaving in lowering the haemagglutinating activity in all the tribal pulses studied. Differences in the effects of different cooking procedures on haemagglutinating activity in the same species, may be due to the extent to which the haemagglutinin molecules in the food particles are exposed to heating and this might in turn be effected by the association of haemagglutinin molecules with other macromolecules (Batra, 1987).

Only moderate loss of phytate occurs in *Abrus precatorius, Mucuna monosperma* (Kerala germplasm), *M.pruriens* and *Prosopis chilensis* (Tables 82, 90, 94 and 96, respectively) when autoclaved at 15 psi (121°C) for different time intervals. It is in consonance with the previous findings in *Vigna aconitifolia* (Khokhar and Chauhan, 1986) and different varieties of black gram (Duhan *et al.*, 1989). Among all the tribal pulses studied, *Dolichos lablab* var. *vulgaris* (Table 88) exhibits minimum loss of phytic acid followed by *Vigna sinensis* (Table 100) under autoclaving. This gains support from the observations of Kataria *et al* (1988) in black gram. The reduction of phytic acid ranging between 21 and 27% in *Bauhinia purpurea, Canavalia gladiata, Mucuna monosperma* (Tamil Nadu germplasm) and *Vigna aconitifolia* (Tables 84, 86, 92 and 98, respectively) is in conformity with the previous reports of Duhan *et al* (1989) in different varieties of chickpea and Uzogara *et al* (1990) in cowpea.
Compared to cooking, autoclaving causes less loss in phytic acid content in all the tribal pulses investigated except *Mucuna monosperma* (Kerala germplasm) (Tables 10 and 90), *M. pruriens* (Tables 14 and 94) and *Prosopis chilensis* (Tables 16 and 96). Ologhobo and Fetuga (1984a) and Uzogara *et al* (1990) also have observed that autoclaving causes less loss of phytic acid in cooked beans compared to cooking by atmospheric boiling.

In general, autoclaving is known to be the best method in decreasing the contents of HCN compared to ordinary cooking. Invariably in all the tribal pulses studied except *Bauhinia purpurea* (Table 84) exhibit significant reduction of HCN content when subjected to autoclaving. In *Bauhinia purpurea* the loss in HCN content seems to be more or less half to its original level in raw seeds. The amount of reduction of HCN seems to be directly related to the duration of autoclaving.

The raffinose content of *Bauhinia purpurea* (Table 84) and *Vigna aconitifolia* (Table 98) is reduced to 81% and 82%, respectively, during autoclaving. Similar results have been obtained earlier in *Cajanus cajan* and *Cicer arietinum* (Jood *et al*., 1985). *Abrus precatorius, Canavalia gladiata, Dolichos lablab var. vulgaris, Prosopis chilensis* and *Vigna sinensis* (Tables 82, 86, 88, 96 and 100, respectively) exhibit reduction of raffinose content ranging from 63% to 73% when autoclaved irrespective of time interval. *Mucuna monosperma* (Kerala and Tamil Nadu germplasm) and *M. pruriens* (Tables 90, 92 and 94, respectively) exhibit a loss of raffinose content ranging from 45 to 59% compared to raw seeds. Significant reduction of stachyose content has been observed in all the tribal pulses investigated. Except *Mucuna monosperma* (Tamil Nadu germplasm) (Table 92) all the other tribal pulses studied show maximum reduction of verbascose content when subjected to autoclaving. These results are in line with earlier observation of Jood *et al* (1985) in *Cajanus cajan, Cicer arietinum, Phaseolus mungo, P. vulgaris* and *Vicia faba*. In general maximum reduction of all the three oligosaccharides has been observed when subjected to autoclaving compared to the atmospheric cooking.
Cooking, soaking, dry heat treatment and autoclaving are ordinary methods employed in the preparation of food consisting of pulses. As such they provide a convenient, inexpensive, easy and practical means of deactivating or removing the antinutrients from these legumes. While considering from the point of view of nutritional quality of the pulses, the use of wet heat is preferable to the dry heat treatment and soaking processing.