Discussion
Legume seeds are valuable sources of proteins, oils, carbohydrates, minerals and vitamins and play an important role in human nutrition mainly in developing countries (Mohamed and Rangappa, 1992; Yanez et al., 1995). The relative proportions of these chemical constituents largely determine the nutritional quality of seeds (Sgarbieri, 1982; de Lumen, 1990). A high content of both protein and oil is desirable.

Due to increase in population with static yield of pulses during the past 25 years (Malhotra et al., 1988), the per capita availability of pulses has declined sharply (Vijayraghavan, 1981). To meet the increasing requirement of pulses, emphasis is being laid on utilization of non-conventional food legumes (Pandey and Srivastava, 1990; Sharma and Sehgal, 1992b; Rajaram and Janardhanan, 1993b; Siddhuraju et al., 1993; Sotelo et al., 1995a,b; Ortega-Nieblas et al., 1996; Ajah and Madubuike, 1997).

Literature evidence indicates varietal / environmental / locational variations in nutrient composition (Krober, 1970; Bliss et al., 1973; Agrawal and Bhattacharya, 1980; Singh et al., 1983; Welch and Griffiths, 1984; Gandhi et al., 1985; Kumar et al., 1991; El-Sherbeeny and Robertson, 1992; Ajah and Madubuike, 1997; Kochhar and Hira, 1997).

5.1 Proximate composition

5.1.1 Crude protein

Proteins are required for maintenance (replacing the wear and tear in tissue) in adults, for growth in infants and children, for fetal development in pregnancy and milk output during lactation. The relative requirement of proteins of the latter groups are higher than in adults (Narasinga Rao et al., 1989).

Among the two germplasm of Canavalia ensiformis (red- coloured seed coat), the Valacode germplasm seed material contains more crude protein than the Dasukuppam germplasm. Both the germplasm seed materials contain more crude protein than the earlier reports in Canavalia ensiformis (Rajaram and Janardhanan, 1992b; Apata and Ologhobo, 1994; Tepal et al., 1994; Ajah and Madubuike, 1997); C. gladiata (Revilleza et al., 1990; Mohan and Janardhanan, 1994c); C. maritima (Bressani et al., 1987) and C. virosa (Rodrigues and Torne, 1991).
Between the two germplasm of *Canavalia ensiformis* (Maroon-coloured seed coat), the Pathanarrtthetta germplasm registers the highest crude protein content, which is comparable with that of earlier reports in some wild/tribal pulses like *Canavalia ensiformis* (Rajaram and Janardhanan, 1992b); *Mucuna gigantea* (Rajaram and Janardhanan, 1991a) and *Prosopis alba* (Lamarque et al., 1994).

Among the four germplasm of *Canavalia ensiformis*, the Valacode (red-coloured seed coat) germplasm registers the highest crude protein content. These results indicate that there is a significant difference in crude protein among the germplasm. This suggests that crude protein has relationship with location. Similar results are also reported by other investigators (Udayasekhara Rao and Belavady, 1979; Singh et al., 1983; Erskine et al., 1985; Ajah and Madubuike, 1997).

Among the four germplasm of *Canavalia gladiata*, the Kumiza (white-coloured seed coat) germplasm registers the highest crude protein content (30.79%), which also contains more crude protein compared with earlier investigations in *Canavalia gladiata* (Revilleza et al., 1990; Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c); *C. maritima* (Bressani et al., 1987) and *C. rosea* (Abbey and Ibeh, 1987).

All the three germplasm of *Cassia floribunda* appear to have higher crude protein content than the earlier reports in *Cassia alata* (Ukhun and Ifebigh, 1988); *C. floribunda* (Janardhanan, 1993); *C. fistula* (Barthakur et al., 1995) and *C. tora* (Talpada et al., 1980).

Among the three germplasm of *Cassia obtusifolia*, the Sidapura germplasm exhibits the highest level of crude protein (24.83%), which is also higher than that of earlier studies in *Cassia alata* (Ukhun and Ifebigh, 1988); *C. alata*, *C. angustifolia*, *C. didymobotrya*, *C. hirsuta*, *C. multijuga*, *C. marginata* and *C. suratensis* (Kapoor et al., 1973); *C. fistula* (Barthakur et al., 1995); *C. floribunda* (Katoch and Bhowmik, 1983; Janardhanan, 1993); *C. grandis*, *C. marginata*, *C. obtusifolia*, *C. renigera* and *C. siamea* (Pant et al., 1974); *C. laevigata* (Siddharaju et al., 1995c); *C. nodosa* and *C. sieberiana* (Amubode and Fetuga, 1984; Balogun and Fetuga, 1986); *C. obtusifolia* (Vijayakumari et al., 1993b; Mohan and Janardhanan 1995c) and *C. tora* (Katoch and Bhowmik, 1983).

Among the three germplasm seed materials of *Mucuna monosperma*, the Borra village germplasm is found to contain more crude protein content than the other two germplasm presently investigated. This germplasm is found to contain crude protein content comparable to that of the wild pulses, *Mucuna nigricans* (Kapoor et al., 1973) and *M. urens* (Achinewhu, 1984) and higher crude protein content than certain wild/tribal pulses reported earlier (*Mucuna imbricata* and *M. prurita*, Kapoor et al., 1973; *M. monosperma*, Prakash and Misra, 1987; Arulmozhi and Janardhanan, 1992).
Among the presently investigated all the three germplasm seed materials of *Mucuna pruriens*, the Karwar germplasm contains the highest level of crude protein (34.56%). The crude protein content of this germplasm seems to be higher than the different species of the same genus, such as *M. atropurpurea* (Mohan and Janardhanan, 1994e); *M. flagellipes* (Onweluzo et al., 1994); *M. gigantea* (Rajaram and Janardhanan, 1991a); *M. monosperma* (Mohan and Janardhanan, 1995b); *M. pruriens* (Laurena et al., 1991; Rajyalakshmi and Geervani, 1994; Siddhuraju et al., 1996b) and *M. utilis* (Janardhanan and Lakshmanan, 1985; Ravindran and Ravindran, 1988; Mohan and Janardhanan, 1995b).

Among the three germplasm seed materials of *Mucuna pruriens* var. *utilis*, the Valanad (black-coloured seed coat) germplasm exhibits the highest crude protein content (29.33%). This value seems to be higher than the previous findings in different wild/tribal pulses belonging to the genus, *Mucuna*, such as *M. atropurpurea* (Mohan and Janardhanan, 1994e); *M. monosperma* (Arulmozhi and Janardhanan, 1992; Mohan and Janardhanan, 1995b); *M. pruriens* (Rajyalakshmi and Geervani, 1994) and *M. utilis* (Janardhanan and Lakshmanan, 1985; Ravindran and Ravindran, 1988).

### 5.1.2 Crude lipid

Significant differences in respect of oil content is found according to the localities within the same variety. This may be partially due to variability in weather conditions, especially temperature and humidity, which affect the metabolic processes involved in the biosynthesis of lipids. The available minerals in the soil may also affect the oil content by affecting the enzyme system responsible for the biosynthesis of oil (Sakla et al., 1988).

Fat is an important component of diet and serves a number of functions in the body. Fat is a concentrated source of energy and it supplies per unit weight more than twice the energy furnished by either proteins or carbohydrates. It also imparts palatability to a diet and retards stomach emptying time. Presence of fat in the diet is important for the absorption of fat soluble vitamins like vitamin A and carotene present in the diet. Apart from these functions, some fats, particularly those derived from vegetable sources provided what is known as "essential fatty acids" (EFA) which have vitamins like functions in body. These EFA are also important for the structure and function of cells (Narasinga Rao et al., 1989).

The crude lipid content of all the four germplasm seed materials of *Canavalia ensiformis* are found to be more or less equal to that of *Vigna capensis* (Mohan and Janardhanan, 1993b) and higher than the under-exploited legumes such as *Canavalia ensiformis* (Apata and Ologhobo, 1994; Tepal et
Among the four germplasm seed materials of *Canavalia gladiata*, the two white-coloured seed coat germplasm of Hogenekkal (7.34%) and Kumliza (9.12%) register higher crude lipid contents than the two maroon-coloured seed coat germplasm. The crude lipid content of Kumliza germplasm is comparable with that of an earlier study in *Canavalia gladiata* (Mohan and Janardhanan, 1994c).

The crude lipid content of all the three germplasm seed materials of *Cassia floribunda* reported in the present study are found to be more than the earlier reports in certain wild/under-exploited legumes such as *Cassia alata* (Ukhun and Ifebigh, 1988); *C. fistula* and *C. multijuga* (Niranjan and Katiyar, 1979) and *C. nodosa* (Amubode and Fetuga, 1983).

Among the three germplasm seed materials of *Cassia obtusifolia* studied, the Sidapura germplasm exhibits the highest crude lipid content (7.77%). This value is found to be more or less equal to that of the wild / tribal pulses such as *Cassia floribunda* (Janardhanan, 1993); *C. obtusifolia* (Vijayakumari et al., 1993b) and *C. tora* (Talpada et al., 1980).

Among the three germplasm seed material of *Mucuna monosperma* studied, the Borra village germplasm exhibits the highest crude lipid content (11.21%). This value is found to be higher than that of earlier reports in *Mucuna flagellipes* (Onweluzo et al., 1994); *M. gigantea* (Rajaram and Janardhanan, 1991a); *M. monosperma* (Arulmozhi and Janardhanan, 1992) and *M. pruriens* (Mary Josephine and Janardhanan, 1992; Rajyalakshmi and Geervani, 1994; Siddhuraju et al., 1996b).

In the present study, the crude lipid content of the three germplasm seed materials of *Mucuna pruriens* range between 5.73 and 6.39%. These values are found to be more or less equal to that of the under-exploited / tribal pulses such as *Canavalia ensiformis* (Rajaram and Janardhanan, 1992b); *Cassia obtusifolia* (Crawford et al., 1990); *Lupinus albus* (Zdunczyk et al., 1994) and *Phaseolus lunatus* (Rajaram and Janardhanan, 1993a).

The crude lipid content of three germplasm seed materials of *Mucuna pruriens* var. *utilis* range between 6.28 and 7.39%. These values are found to be higher than the under-exploited / tribal legumes under the genus, *Mucuna*, such as *M. monosperma* (Tamil Nadu germplasm) (Arulmozhi and Janardhanan, 1992) and *M. utilis* (Ravindran and Ravindran, 1988).

### 5.1.3 Crude fibre

Fibre in diet comes from complex carbohydrates available in whole grains, fruits and vegetables. Top among the top heavyweights are cooked dried beans or pulses, corn, oat meal and
fruits like pears, apple, guava, grapes etc. The World Health Organisation (WHO) recommends an intake of 22 - 23g of fibre for every 1000 kcal of diet. The National Institute of Nutrition (NIN), Hyderabad, India, on the other hand, has recommended a minimum consumption of 40-50 g of fibre per day. Fibre is an important of food in human nutrition has been recently thoroughly discussed (Kanwar et al., 1997).

All the four germplasm seed materials of *Canavalia ensiformis* are found to contain less crude fibre than earlier studies in *Canavalia ensiformis* (Molina et al., 1974); *C. gladiata* (Bressani et al., 1987; Rodrigues and Torne, 1991) and *C. maritima* (Bressani et al., 1987).

The four germplasm seed materials of *Canavalia gladiata* contain crude fibre in the range of 4.29 - 6.23%. These values are found to be more or less equal to that of *Canavalia ensiformis* (Revilleza et al., 1990; Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c).

All the three germplasm seed materials of *Cassia floribunda* and *C. obtusifolia* are found to contain less crude fibre content than seeds of *lupin* (Zdunczuk et al., 1994; Smulikowska et al., 1995). Among the two species, the three germplasm seed materials of *C. floribunda* exhibit higher range of crude fibre contents (8.57-10.81%).

All the three germplasm seed materials of *Mucuna monosperma* are found to contain less crude fibre than earlier reports in tribal pulses like *Bauhinia malabarica* (Vijayakumari et al., 1993a); *Cassia floribunda* (Janardhanan, 1993) and *Tamarindus indica* (Sidduraju et al., 1995c). Among the three, Bogalthode germplasm exhibits the highest crude fibre content (12.06%).

All the three germplasm seed materials of *Mucuna pruriens* and *M. pruriens* var. *utilis* are found to contain less crude fibre content than *Mucuna gigantea* (Rajaram and Janardhanan, 1991a) and *M. utilis* (Mohan and Janardhanan, 1995b).

5.1.4 Ash

The four germplasm seed materials of *Canavalia ensiformis* are found to contain ash content comparable with that of earlier reports in the same pulse, *C. ensiformis* (Bressani et al., 1987; Revilleza et al., 1990; Rodrigues and Torne, 1991; Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c).

Among the four germplasm seed materials of *Canavalia gladiata*, Kumlza (white-coloured seed coat) germplasm contains the highest level of ash (4.77%). This value is comparable with that of an earlier report in the same pulse (Revilleza et al., 1990).
The ash content of three germplasm seed materials of *Cassia floribunda* range from 3.41 to 5.58%. The Erattupattai germplasm exhibits the highest value of ash content (5.58%) among the three germplasm presently investigated. This value is found to be higher than that of some wild / little known/ tribal pulses such as *Cassia absus* (Pant et al., 1974); *C. alata* (Ukhun and Ifebugh, 1988); *C. fistula* (Barthakur et al., 1995); *C. floribunda* (Janardhanan, 1993); *C. grandis* (Pant et al., 1974); *C. laevigata* (Siddhuraju et al., 1995c); *C. marginata* (Pant et al., 1974); *C. nodosa* (Amubode and Fetuga, 1983); *C. obtusifolia* (Crawford et al., 1990; Vijayakumari et al., 1993b; Mohan and Janardhanan, 1995c); *C. occidentalis*, *C. renigera* and *C. siamea* (Pant et al., 1974); *C. tora* (Katoch and Bhowmik, 1983) and *C. uniflora* (Vijaya Bhanu et al., 1991).

Among the three germplasm seed materials of *Cassia obtusifolia* presently investigated, the Courtallum germplasm exhibits the highest ash content (5.83%). This value is found to be higher than that of earlier reports in the same species (Crawford et al., 1990; Vijayakumari et al., 1993b; Mohan and Janardhanan, 1995c).

Among the three germplasm seed materials of *Mucuna monosperma*, the Borra village germplasm exhibits the highest level of ash content (4.15%). This value is found to be higher than that of earlier reports in the same species (Arulmozhi and Janardhanan, 1992; Mohan and Janardhanan, 1995b).

The ash content of the three germplasm seed materials of *Mucuna pruriens* range from 3.74 to 4.65%. This range is found to be more or less equal that of earlier reports in the same species, *M. pruriens* (Pant et al., 1974; Siddhuraju et al., 1996b).

Among the three germplasm seed materials of *Mucuna pruriens* var. *utilis*, the Thachenmalai (white-coloured seed coat) germplasm exhibits the highest ash content (5.45%). This value is found to be higher than that of little known / tribal pulses such as *Mucuna monosperma* (Arulmozhi and Janardhanan, 1992; Mohan and Janardhanan, 1995b); *M. pruriens* (Rajyalakshmi and Geervani, 1994; Siddhuraju et al., 1996b) and *M. utilis* (Ravindran and Ravindran, 1988; Mohan and Janardhanan, 1995b).

5.1.5 Nitrogen Free Extractives (NFE)

In the present study, the NFE contents of *Canavalia ensiformis* (four germplasm), *C. gladiata* (four germplasm), *Cassia floribunda* (three germplasm), *C. obtusifolia* (three germplasm), *Mucuna monosperma* (three germplasm), *M. pruriens* (three germplasm) and *M. pruriens* var. *utilis* (three germplasm) are found to be in the range of 49.15 - 54.49%, 51.03-63.40%, 61.02-63.28%, 56.49-
60.29%, 53.13-59.18%, 49.14-58.90% and 51.66-63.15%, respectively. These values are found to be higher than that of some previous studies in the little known/tribal pulses like Canavalia ensiformis, C. gladiata and C. maritima (Bressani et al., 1987); Mucuna gigantea (Rajaram and Janardhanan, 1991a) and M. utilis (Mohan and Janardhanan, 1995b).

5.1.6 Calorific value

The energy requirement of an individual is the level of energy intake from food that will balance energy expenditure when the individual has a body size and composition and level of physical activity, consistent with long term good health and that will allow for maintenance of economically necessary and socially desirable activity. In children and pregnant and lactating women, the energy requirement includes the energy needs associated with the deposition of tissues or the secretion of milk at rates consistent with good health (FAO/WHO/UNU, 1985).

Energy intake far above the actual requirement is harmful, leading to hazards of obesity and its health consequences. On the other hand, energy intakes far below the requirement leads to undernutrition and loss of body weight. Hence, in contrast to many other nutrients, no safe allowance is made in the case of energy and only the average requirements are defined (ICMR, 1992).

Energy requirement of infants as recommended by the FAO/WHO/UNU (1985) is adopted for Indian infants also (ICMR, 1992).

The energy values for different ages during infancy and children are given as Tables I and II.


<table>
<thead>
<tr>
<th>Age (months)</th>
<th>kJ / Kg body weight / day</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 3</td>
<td>485</td>
</tr>
<tr>
<td>3 - 6</td>
<td>415</td>
</tr>
<tr>
<td>6 - 9</td>
<td>400</td>
</tr>
<tr>
<td>9 - 12</td>
<td>420</td>
</tr>
<tr>
<td>Average during the first year</td>
<td>430</td>
</tr>
</tbody>
</table>
Table II Energy requirement of children aged 1 - 10 years (FAO / WHO / UNU, 1985)

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>kJ / kg body weight / day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
</tr>
<tr>
<td>1 - 3</td>
<td>435</td>
</tr>
<tr>
<td>2- 3</td>
<td>410</td>
</tr>
<tr>
<td>3 - 4</td>
<td>414</td>
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<tr>
<td>4 - 5</td>
<td>397</td>
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<tr>
<td>5 - 6</td>
<td>385</td>
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<tr>
<td>6 - 7</td>
<td>368</td>
</tr>
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<td>7 - 8</td>
<td>347</td>
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<tr>
<td>8 - 9</td>
<td>322</td>
</tr>
<tr>
<td>9 - 10</td>
<td>301</td>
</tr>
</tbody>
</table>

In the present study, the calorific value (energy) of the seed materials of Canavalia ensiformis (four germplasm), C. gladiata (four germplasm), Cassia floribunda (three germplasm), C. obtusifolia (three germplasm), Mucuna monosperma (three germplasm), M. pruriens (three germplasm) and M. pruriens var. utilis (three germplasm) are found to be in the range of 1511.00 - 1567.75, 1566.76 - 1710.22, 1466.57 - 1497.42, 1576.97 - 1650.97, 1620.27 - 1682.47, 1601.45 - 1635.35 and 1496.99 - 1594.23 kJ 100g⁻¹ dry matter, respectively.

In the present study, among all the germplasm seed materials, the germplasm of Canavalia ensiformis (four germplasm) (28.88 - 35.02%); C. gladiata (four germplasm) (24.30 - 30.79%); Cassia obtusifolia (Sidapura) (24.83%); Mucuna pruriens (three germplasm) (24.99 - 34.56%) and M. pruriens var. utilis (Valanad, black and white-coloured seed coat) (29.33% and 26.69%) are found to contain higher range of crude protein. Nonetheless, the germplasm seed materials of Cassia floribunda (three germplasm) (19.85 - 21.67%); C. obtusifolia (Topslip and Courtallum) (20.34 and 21.30%); Mucuna monosperma (three germplasm) (21.21 - 22.28%) and M. pruriens var. utilis (Keriparai, black-coloured seed coat) (20.24%) are found to contain lower levels of crude protein (Tables 1-9). However, the crude protein content of all the species/germplasm seed materials of the
present study are found to be higher than that of commonly cultivated legumes like *Cajanus cajan* (Nwokolo, 1987; Kumar et al., 1991; Mnembuka and Eggum, 1995); *Cicer arietinum* (Meiners et al., 1976a; Srivastav et al., 1990; Hira and Chopra, 1995) and *Phaseolus vulgaris* (Barampama and Simard, 1995).

Among all the germplasm seed materials of the present study, the germplasm of *Canavalia gladiata* (both the white-coloured seed coat) (7.34 and 9.12%); *Cassia obtusifolia* (three germplasm) (6.56-7.77%); *Mucuna monosperma* (three germplasm) (7.27-11.21%); *M. pruriens* (three germplasm) (5.73-6.39%) and *M. pruriens* var. *utilis* (three germplasm) (6.28 - 7.39%) are found to contain more crude lipid content than the other presently investigated species/germplasm (Tables 1-9). However, all the germplasm seed materials of the present study are found to contain more crude lipid content than that of commonly cultivated legumes like *Cajanus cajan* (Kumar et al., 1991; Igbedioh et al., 1995); *Phaseolus vulgaris* (Meiners et al., 1976a; Apata and Ologhobo, 1994; Barampama and Simard, 1995); *Vigna mungo* (= *Phaseolus mungo*) and *V. radiata* (= *Phaseolus aureus*) (Gupta and Wagle, 1978) and *V. unguiculata* (Nwokolo and Oji, 1985; Aremu, 1990).

In the present study, all the germplasm seed materials are found to contain more crude fibre than that of commonly cultivated pulses like *Cajanus cajan* (Oshodi and Ekperigin, 1989; Igbedioh et al., 1994); *Cicer arietinum* (Hira and Chopra, 1995); *Phaseolus vulgaris* (Singh and Sood, 1997); *Vigna mungo* (Gupta and Wagle, 1978; Rajyalakshmi and Geervani, 1994) and *V. unguiculata* (Akinyele, 1989).

The ash content of the germplasm of *Canavalia ensiformis* (Dasukuppam, red and Maananthavaadi, maroon-coloured seed coat); *C. gladiata* (Kumtza, white-coloured seed coat); *Cassia floribunda* (Kumtza and Erattupattai); *C. obtusifolia* (three germplasm); *Mucuna monosperma* (Borra village); *M. pruriens* (Karwar) and *M. pruriens* var. *utilis* (Valanad, black and Thachennalai, white-coloured seed coat) are found to be higher than that of commonly cultivated legumes like *Cajanus cajan* (Apata and Ologhobo, 1994; Igbedioh et al., 1994; Rajyalakshmi and Geervani, 1994; Mnembuka and Eggum, 1995); *Cicer arietinum* (Sotelo et al., 1987; Srivastav et al., 1990; Attia et al., 1994a,b); *Phaseolus vulgaris* (Barampama and Simard, 1995); *Vigna mungo* (Gupta and Wagle, 1978; Rajyalakshmi and Geervani, 1994); *V. radiata* (Gupta and Wagle, 1978; Sharma et al., 1991) and *V. unguiculata* (Mnembuka and Eggum, 1993; 1995).
In the present study, all the species/germplasm seed materials are found to contain higher percentage of NFE compared with *Glycine max* (Gandhi et al., 1984; Shukla et al., 1987; Sakla et al., 1988; Saxena et al., 1994).

Due to the presence of higher contents of crude protein and crude lipid, the germplasm of *Canavalia ensiformis* (Valacode, red and Pathanamthitta, maroon-coloured seed coat); *C. gladiata* (Courtallum, maroon and Kumlza, white-coloured seed coat); *Cassia floribunda* (Kargal); *C. obtusifolia* (Sidapura); *Mucuna monosperma* (Borra village) *M. pruriens* (Kanwar) and *M. pruriens* var. *utilis* (Valanad, black and Thachenmalai, white-coloured seed coat) are found to contain higher calorific value compared to other germplasm of the same species (Tables 1-9).

### 5.2 Total (true) protein and protein fractions

#### 5.2.1 Total (true) protein

In the present study, among all the four germplasm seed materials of *Canavalia ensiformis*, the Valacode (red-coloured seed coat) germplasm exhibits the highest total (true) protein content. The true protein content of this germplasm seems to be higher compared with earlier reports in *Canavalia ensiformis* (Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c).

Except Paramangalam (maroon - coloured seed coat) germplasm, all the other three germplasm seed materials of *Canavalia gladiata* of the present study are found to contain more true protein compared to earlier investigations in the same species (Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c). Among all the four germplasm seed materials, the Kumlza (white - coloured seed coat) germplasm registers the highest true protein content (29.52%).

All the three germplasm seed materials of *Cassia floribunda* and *C. obtusifolia* are found to contain more true protein than that of earlier reports in *Cassia floribunda* (Janardhanan, 1993) and *C. laevigata* (Siddhuraju et al., 1995c). Among the *Cassia* species, the Sidapura germplasm of *C. obtusifolia* exhibits the highest true protein content (22.68%).

Among all the three germplasm seed materials of *Mucuna monosperma*, the Borra village germplasm registers the highest true protein value (18.93%) and this value is comparable to that of *Entada scandens* and *Phaseolus lunatus* (Vijayakumari et al., 1993b); *Vigna calcaratus* (Rajaram and Janardhanan, 1992d) and *V. capensis* (Mohan and Janardhanan, 1993b).

In the present study all the three germplasm seed materials of *Mucuna pruriens* are found to contain more true protein than that of some wild / tribal pulses like *Mucuna atropurpurea* (Rajaram and Janardhanan, 1992c; Mohan and Janardhanan, 1994e); *M. gigantea* (Rajaram and Janardhanan,
1991a); *M. monosperma* (Arulmozhi and Janardhanan, 1992; Mohan and Janardhanan, 1995b) and *M. utilis* (Mohan and Janardhanan, 1995b).

Among all the three germplasm seed materials of *Mucuna pruriens* var. *utilis*, the Valanad (black-coloured seed coat) germplasm registers the highest true protein level (25.74%). This value seems to be higher than that of an earlier report in the same species (Mohan and Janardhanan, 1995b).

In the present study, the germplasm seed materials of *Canavalia ensiformis* (four germplasm), *C. gladiata* (Courtallum, maroon and Hogenekkal and Kumliza, white-coloured seed coat), *Cassia obtusifolia* (Sidapura), *Mucuna pruriens* (three germplasm) and *M. pruriens* var. *utilis* (Valanad, black and Thachenmalai, white-coloured seed coat) are found to contain higher true protein levels than that of cultivated legumes like black gram and green gram (Gupta and Wagle, 1978) and field pea and vegetable pea (Saharan and Khetarpaul, 1994).

### 5.2.2 Protein fractions

In general, the globulins constitute the major seed storage protein in legumes (Boulter and Derbyshire, 1976; Singh and Jambunathan, 1982; Murray, 1984; Singh and Eggum, 1984; Singh et al., 1985; Krochko and Bewley, 1988).

The data presented in Tables 10-18 reveal that in all the presently investigated tribal pulses, globulins and albumins are found to be the major seed protein fractions. This is in agreement with some of the earlier investigations in wild/tribal pulses such as *Canavalia ensiformis* and *C. gladiata* (Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c); *Cassia obtusifolia* (Mohan and Janardhanan, 1995c); *Mucuna atropurpurea* (Mohan and Janardhanan, 1994e); *M. gigantea* (Rajaram and Janardhanan, 1991a); *M. monosperma* (Mohan and Janardhanan, 1995b); *M. pruriens* (Mary Josephine and Janardhanan, 1992; Siddhuraju et al., 1996b) and *M. utilis* (Mohan and Janardhanan, 1995b).

In general, in the present study, all the investigated tribal pulses exhibit relatively high proportion of albumins when compared with some of the commonly consumed pulses such as *Cajanus cajan* (Mahajan et al., 1988); *Cicer arietinum* (Singh and Jambunathan, 1982) and *Vigna mungo* (Mahajan et al., 1988). The occurrence of high levels of albumins seem to be nutritionally significant because of the presence of relatively high levels of essential amino acids especially cystine and methionine (Murray and Roxburg, 1984; Siddhuraju et al., 1995a,b,c) and tryptophan (Siddhuraju et al., 1997a).
5.3 Amino acid composition

To assess the potential food value of the seed proteins as source of amino acids, the levels of essential amino acids (valine, cystine, methionine, threonine, phenylalanine, tyrosine, isoleucine, leucine, histidine, lysine and tryptophan) of seed proteins have to be compared with FAO/WHO (1991) requirement pattern.

In *Canavalia ensiformis* (both the red-coloured seed coat), the amino acids, leucine and lysine and in *C. ensiformis* (both the maroon-coloured seed coat), the valine, isoleucine, leucine and lysine are deficient compared to FAO/WHO (1991) requirement pattern. The lysine and methionine contents of all the four germplasm seed materials of the present study seem to be higher than the content of lysine in peanuts (Mnembuka and Eggum, 1993) and methionine in cowpea (Aremu, 1990; Ene-Obong and Carnovale, 1992; Chan and Phillips, 1994). The contents of valine and isoleucine of both the red-coloured seed coat germplasm seed proteins of *C. ensiformis* are found to be higher than both the maroon-coloured seed coat germplasm seed proteins and FAO/WHO (1991) requirement pattern. The essential amino acid contents of threonine, phenylalanine, tyrosine and histidine of all the four germplasm seed proteins are present in more than adequate levels when compared with FAO/WHO (1991) requirement pattern.

The amino acids, leucine and lysine, in the maroon-coloured seed coat (both) germplasm of *Canavalia gladiata* seem to be deficient; whereas the levels of valine, threonine, phenylalanine, tyrosine, isoleucine and histidine are found to be higher compared to FAO/WHO (1991) requirement pattern. In both the white-coloured seed coat germplasm seed proteins of *C. gladiata*, the valine, threonine, phenylalanine, tyrosine, isoleucine, leucine, histidine and lysine contents are present in more than adequate levels when compared to FAO/WHO (1991) requirement pattern. The methionine content of all the four germplasm seed proteins of *C. gladiata* are found to be higher than that of black gram (Padhye and Salunkhe, 1979).

The threonine content of all three germplasm of *Cassia floribunda* seed proteins and leucine content of Erattupattai and Kargal germplasm seem to be deficient; whereas valine, phenylalanine, tyrosine, isoleucine, histidine and lysine contents of all the three germplasm and leucine content of Kumlza germplasm seed proteins are found to be higher than FAO/WHO (1991) requirement pattern. The valine content of all the three germplasm are found to be higher than that of *Phaseolus vulgaris* (Sotelo et al., 1995b).
The content of threonine in Courtallum and Topslip germplasm seed proteins of Cassia obtusifolia seem to be deficient; whereas valine, phenylalanine, tyrosine, isoleucine, leucine, histidine and lysine contents of all the three germplasm and threonine content in Sidapura germplasm seed proteins alone appear to be present in more than adequate levels compared to FAO/WHO (1991) requirement pattern. The deficient threonine content in Courtallum and Topslip germplasm seed proteins of C. obtusifolia is found to be higher compared with threonine contents of black gram and green gram (Gupta and Wagle, 1978).

The content of leucine in seed proteins of all the three germplasm seed proteins of Mucuna monosperma is found to be deficient compared to FAO/WHO (1991) requirement pattern. The lysine content of Bogalthode germplasm alone is found to be deficient; when compared with earlier investigations in the same species, this value is found to be higher (Arulmozhi and Janardhanan, 1992; Mohan and Janardhanan, 1995b). The valine, threonine, phenylalanine, tyrosine, isoleucine and histidine contents of all the three germplasm seed proteins and lysine content of Chittoor and Borra village germplasm are found to be higher than FAO/WHO (1991) requirement pattern.

The threonine and lysine contents of all the three germplasm seed proteins of Mucuna pruriens are found to be deficient; whereas the contents of valine, phenylalanine, tyrosine, isoleucine, leucine and histidine are present in more than FAO/WHO (1991) requirement levels. The threonine content of seed proteins of all the three germplasm seems to be more or less equal to that of Cicer arietinum (Singh et al., 1988). The valine and tyrosine contents of all the three germplasm seed proteins of M. pruriens seem to be higher than that of some common legumes such as Cajanus cajan (Singh et al., 1981a; Apata and Ologhobo, 1994); Cicer arietinum (Singh et al., 1988) and Vigna mungo and V. radiata (Ignacimuthu and Babu, 1987).

The contents of threonine, leucine and lysine in black-coloured (both) seed coat and phenylalanine and tyrosine in white-coloured seed coat (Thachenmalai) germplasm seed proteins of Mucuna pruriens var. utilis seem to be deficient; whereas valine, isoleucine and histidine in all three germplasm and threonine, leucine and lysine in Thachenmalai germplasm and phenylalanine and tyrosine in Keriparai and Valanad (black-coloured seed coat) germplasm seed proteins are found to be higher compared to FAO/WHO (1991) requirement pattern. The threonine and lysine contents of Keriparai and Valanad germplasm seed proteins are found to be higher than threonine contents of black gram and green gram (Gupta and Wagle, 1978) and lysine content of black gram (Padhye and Salunkhe, 1979). The valine content of all the three germplasm seed proteins seems to be higher when
compared with common cultivated legumes like black gram (Padhye and Salunkhe, 1979; Ignacimuthu and Babu, 1987); chickpea (Singh et al., 1988; Dhawan et al., 1991); cowpea (Aremu, 1990; Ene-Obong and Carnovale, 1992; Chan and Phillips, 1994); green gram (Gupta and Wagle, 1978; Ignacimuthu and Babu, 1987); pigeonpea (Singh et al., 1981a; Apata and Ologhobo, 1994) and soybean (Ologhobo and Fetuga, 1984).

In general all the species/germplasm seed proteins, except maroon-coloured seed coat of *Canavalia ensiformis* (Maananthavaadi and Pathanamthetta), seem to exhibit high valine content compared to FAO/WHO (1991) requirement pattern.

The threonine content of the germplasm seed proteins of *Cassia floribunda* (three germplasm), *C. obtusifolia* (Courtallum and Topslip), *Mucuna pruriens* (three germplasm) and *M. pruriens var. utilis* (Keriparai and Valanad, black-coloured seed coat) are found to be deficient; whereas all the other species/germplasm seed proteins of the present study are found to contain more threonine content than that of FAO/WHO (1991) requirement pattern.

The phenylalanine and tyrosine contents of all the species/germplasm seed proteins, except Thachenmalai (white-coloured seed coat) germplasm of *Mucuna pruriens var. utilis*, are found to exhibit more than adequate levels compared to FAO/WHO (1991) requirement pattern.

The isoleucine content of seed proteins of *Canavalia ensiformis* (Maananthavaadi and Pathanamthetta, maroon-coloured seed coat) is deficient; whereas in all the other different species/germplasm seed proteins of the present study, the isoleucine content appears to be higher than FAO/WHO (1991) requirement pattern.

In the seed proteins, except *Canavalia gladiata* (Hogenekkal and Kumlza, white-coloured seed coat); *Cassia floribunda* (Kumlza); *C. obtusifolia* (three germplasm); *Mucuna pruriens* (three germplasm) and *M. pruriens var. utilis* (Thachenmalai, white-coloured seed coat), leucine content is found to be deficient compared to FAO/WHO (1991) requirement pattern.

In all the different species/germplasm seed proteins of the present study occurrence of adequate levels of histidine compared to FAO/WHO (1991) requirement pattern has been recorded.

The lysine content of all the species/germplasm seed proteins, except *Canavalia gladiata* (Hogenekkal and Kumlza, white-coloured seed coat); *Cassia floribunda* (three germplasm); *C. obtusifolia* (three germplasm); *Mucuna monosperma* (Chitoor and Borra village) and *M. pruriens var. utilis* (Thachenmalai, white-coloured seed coat), are deficient compared to FAO/WHO (1991) requirement pattern.
5.4 Mineral composition

The essentiality of a number of minerals has been known for many years and estimated dietary requirements for five of them (calcium, phosphorus, iron, copper and iodine) have been proposed in the 1939 "Year - book of Agriculture, Food and Life" (Sherman et al., 1939). The third edition of the Recommended Dietary Allowances (RDA), published in 1953 includes RDA's for only two minerals, calcium and iron, although phosphorus, copper and iodine are recognised as essential (Bogert, 1954). The number of elements with dietary recommendations have expanded to twelve by National Research Council (NRC/NAS, 1980) and remained at twelve when the most recent edition of the RDA is published (NRC/NAS, 1989). The 1980 recommendations include six minerals with RDA's and six with Estimated Safe and Adequate Daily Dietary Intakes (ESADDI), while the 1989 recommendations include seven with RDA's and five with ESADDI (Turnlund, 1994).

In the present study, the mineral composition of different species/germplasm seed materials is compared with RDA and ESADDI of NRC/NAS (1980; 1989) and Indian Council of Medical Research (ICMR, 1992).

The electrolyte sodium content of all the four germplasm seed materials of *Canavalia ensiformis* investigated presently is found to be higher than that of an earlier report in *C. ensiformis* (Rajaram and Janardhanan, 1992b). Among the four, Dasukuppam (red-coloured seed coat) germplasm registers the highest content of sodium (114.53 mg 100g\(^{-1}\) seed flour). This value seems to be higher when compared with a previous analysis in *C. ensiformis* (Mohan and Janardhanan, 1994c).

All the four germplasm seed materials of *Canavalia ensiformis* exhibit higher levels of potassium content than some wild / little known legumes such as *Prosopis juliflora* (Marangoni and Alii, 1988) and *Tamarindus indica* (Ishola et al., 1990). Among the four, Valacode (red-coloured seed coat) germplasm registers the highest level of potassium (1017.47 mg 100g\(^{-1}\) seed flour). This value seems to be more or less equal to that of some tribal pulses such as *Bauhinia vahlia* (Rajaram and Janardhanan, 1991b) and *Xyilia xylocarpa* (Siddhuraju et al., 1995a).

The calcium content of all the four germplasm seed materials of *Canavalia ensiformis* is found to be higher than an earlier study in the same species (Rodrigues and Torne, 1991). Among the four, Valacode (red-coloured seed coat) germplasm exhibits the highest content of calcium (497.91 mg 100g\(^{-1}\) seed flour). This value seems to be higher than that of *C. ensiformis* (Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c).
The magnesium content of all the four germplasm seed materials of *Canavalia ensiformis* appears to be higher when compared with earlier reports in *Canavalia ensiformis* (Bressani et al., 1987; Rodrigues and Tomé, 1991; Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c); *C. maritima* (Bressani et al., 1987) and *C. virosa* (Rodrigues and Tomé, 1991). Among the four, Dasukuppam (red-coloured seed coat) germplasm registers the highest amount of magnesium (281.94 mg 100g\(^{-1}\) seed flour).

All the four germplasm seed materials of *Canavalia ensiformis* are found to contain more phosphorus content than that of an earlier report in the same species (Rodrigues and Tomé, 1991). Among the four germplasm investigated, Pathanamthetta (Maroon-coloured seed coat) germplasm registers the highest amount of phosphorus (467.27 mg 100g\(^{-1}\) seed flour).

The iron content of all the four germplasm seed materials of *Canavalia ensiformis* is found to be higher when compared with the iron content of an earlier report in *Canavalia gladiata* (Rajaram and Janardhanan, 1992b). Among the four, Valacode (red-coloured seed coat) germplasm registers the highest content of iron (5.18 mg 100g\(^{-1}\) seed flour). This value seems to be higher than that of *Canavalia ensiformis* (Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c).

Among the four germplasm seed materials of *Canavalia ensiformis*, the Valacode (red-coloured seed coat) germplasm exhibits the highest content of copper (0.38 mg 100g\(^{-1}\) seed flour). This value appears to be more or less equal to that of an earlier report in the same legume (Rajaram and Janardhanan, 1992b).

The micro element, zinc, content of all the four germplasm seed materials of *Canavalia ensiformis* is found to be higher when compared with that of earlier reports in the same species (Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c). Among the four, Dasukuppam (red-coloured seed coat) germplasm registers the highest content of zinc element (4.42 mg 100g\(^{-1}\) seed flour). This value seems to be higher than that of *Canavalia ensiformis*, *C. gladiata* and *C. maritima* (Bressani et al., 1987).

The manganese content of all the four germplasm seed materials of *Canavalia ensiformis* is found to be higher than the reports of Rajaram and Janardhanan (1992b) and Mohan and Janardhanan (1994c), in the same species. Among the four, Valacode (red-coloured seed coat) and Pathanamthetta (maroon-coloured seed coat) germplasm exhibit equal amounts of manganese content (0.98 mg 100g\(^{-1}\) seed flour). This value seems to be higher than that of *Canavalia ensiformis*, *C. gladiata* and *C. maritima* (Bressani et al., 1987).
All the four germplasm seed materials of *Canavalia gladiata* presently investigated are found to contain higher content of sodium when compared with that of an earlier report in *Canavalia gladiata* (Rajaram and Janardhanan, 1992b). Among the four, Hogenekkal (white-coloured seed coat) germplasm registers the highest level of sodium (173.25 mg 100g\(^{-1}\) seed flour). This value seems to be higher than an earlier report in *C. gladiata* (Mohan and Janardhanan, 1994c).

The potassium and calcium contents of all the four germplasm seed materials of *Canavalia gladiata* appear to be higher when compared with that of *Canavalia ensiformis*, *C. gladiata* and *C. maritima* (Bressani et al., 1987). Among the four, Courtallum (maroon-coloured seeds coat) germplasm exhibits the highest level of potassium (1639.52 mg 100g\(^{-1}\) seed flour) and calcium (510.08 mg 100g\(^{-1}\) seed flour).

All the four germplasm seed materials of *Canavalia gladiata* are found to contain higher amounts of magnesium and phosphorus compared to that of *Canavalia ensiformis* (Rodrigues and Torne, 1991; Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c); *C. gladiata* (Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c); *C. maritima* (Bressani et al., 1987) and *C. virosa* (Rodrigues and Torne, 1991). Among the four, Courtallum (maroon-coloured seed coat) germplasm exhibits the highest amount of magnesium (480.93 mg 100g\(^{-1}\) seed flour) and phosphorus (601.16 mg 100g\(^{-1}\) seed flour).

Among the four germplasm seed materials of *Canavalia gladiata*, the Courtallum (maroon-coloured seed coat) germplasm is found to contain the highest amounts of iron, copper and zinc (10.93, 0.83 and 6.56 mg 100g\(^{-1}\) seed flour, respectively). The iron, copper and zinc contents of this germplasm appear to be higher compared to that of *Canavalia ensiformis* and *C. gladiata* (Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c).

The manganese content of all the four germplasm seed materials of *Canavalia gladiata* are found to be higher compared to that of *Canavalia ensiformis* and *C. gladiata* (Bressani et al., 1987; Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c) and *C. maritima* (Bressani et al., 1987). Among the flour, Hogenekkal (white-coloured seed coat) germplasm registers the highest content of manganese (4.33 mg 100g\(^{-1}\) seed flour).

All the three germplasm seed materials of *Cassia floribunda* investigated presently are found to contain more sodium content compared to that of some little known / tribal pulses such as *Canavalia ensiformis* and *C. gladiata* (Rajaram and Janardhanan, 1992b); *Mucuna gigantea* (Rajaram and Janardhanan, 1991a) and *M. monosperma* (Mohan and Janardhanan, 1995b). Among the three, Kargal
germplasm registers the highest level of sodium (135.88 mg 100g\(^{-1}\) seed flour). This level seems to be higher than that of *Cassia laevigata* (Siddharaju et al., 1995c) and *C. obtusifolia* (Vijayakumari et al., 1993b; Mohan and Janardhanan, 1995c).

Among the three germplasm seed materials of *Cassia floribunda*, the Erattuppattai germplasm exhibits the highest content of potassium (912.90 mg 100g\(^{-1}\) seed flour). This value seems to be higher than that of an earlier study in *Cassia floribunda* (Janardhanan, 1993).

The calcium content of the three germplasm seed materials of *Cassia floribunda* appears to be higher compared to that of some wild / little known legumes like *Albizia lebbeck*, *Acacia gaumeri*, *Caesalpinia yucatanensis*, *C. vesicaria*, *Leucaena leucocephala*, *Lonchocarpus longystilus*, *Pithecellobium keyense* and *P. saman* (Sotelo et al., 1995a). Among the three, Erattuppattai germplasm registers the highest content of calcium (549.39 mg 100g\(^{-1}\) seed flour). This value seems to be higher compared to that of an earlier report in the same species (Janardhanan, 1993).

All the three germplasm seed materials of *Cassia floribunda* are found to contain more magnesium compared to that of *Cassia laevigata* (Siddharaju et al., 1995c). Among the three, Erattuppattai germplasm registers the highest amount of magnesium (318.26 mg 100g\(^{-1}\) seed flour).

The phosphorus and iron contents of all the three germplasm seed materials of *Cassia floribunda* are found to be higher compared to an earlier investigation (Janardhanan, 1993). Among the three, Kumlza germplasm exhibits the highest levels of phosphorus and iron (638.50 and 5.68 mg 100g\(^{-1}\) seed flour, respectively). The contents of phosphorus and iron of this germplasm are found to higher compared to that of the contents of phosphorus and iron in *Cassia obtusifolia* (Mohan and Janardhanan, 1995c).

Among the three germplasm seed materials, the Kargal germplasm seed material of *Cassia floribunda* exhibits the highest content of copper and zinc elements (0.28 and 1.96 mg 100g\(^{-1}\) seed flour, respectively). The copper and zinc contents of this germplasm appear to be higher compared to that of copper and zinc contents of *Vigna glabrescens* and *V. sublobata* (Rajaram and Janardhanan, 1992d).

The manganese content of all the three germplasm seed materials of *Cassia floribunda* are found to be higher compared to that of *Vigna calcaratus*, *V. glabrescens* and *V. sublobata* (Rajaram and Janardhanan, 1992d) and *V. umbellata* (Mohan and Janardhanan, 1994d). Among the three, Erattuppattai germplasm registers the highest level of manganese (1.04 mg 100g\(^{-1}\) seed flour).
Among the three germplasm seed materials of Cassia obtusifolia, the Sidapura germplasm exhibits the highest content of sodium (144.71 mg 100g⁻¹ seed flour). This value seems to be higher compared to that of Cassia laevigata (Siddhuraju et al., 1995c) and C. obtusifolia (Vijayakumari et al., 1993b; Mohan and Janardhanan, 1995c).

Among the three germplasm seed materials of Cassia obtusifolia of the present study, the Topslip germplasm exhibits the highest content of potassium (1555.79 mg 100g⁻¹ seed flour). This value seems to be higher compared to that of Cassia floribunda (Janardhanan, 1993), C. laevigata (Siddhuraju et al., 1995c) and C. obtusifolia (Vijayakumari et al., 1993b).

All the three germplasm seed materials of Cassia obtusifolia are found to contain higher levels of calcium content compared to that of Cassia absus, C. grandis, C. obtusifolia, C. occidentalis, C. renigera and C. siamea (Pant et al., 1974). Among the three, Courtallum germplasm registers the highest content of calcium (768.17 mg 100g⁻¹ seed flour).

The contents of magnesium and phosphorus of all the three germplasm seed materials of Cassia obtusifolia are found to be comparable with that of magnesium and phosphorus contents of Cassia floribunda (Janardhanan, 1993) and C. laevigata (Siddhuraju et al., 1995c). Among the three, Courtallum germplasm registers the highest content of magnesium (709.49 mg 100g⁻¹ seed flour) and Topslip germplasm registers the highest content of phosphorus (947.79 mg 100g⁻¹ seed flour).

Among the three germplasm seed materials of Cassia obtusifolia, the Courtallum germplasm registers the highest content of iron (12.35 mg 100g⁻¹ seed flour). This value seems to be higher than that of Cassia floribunda (Janardhanan, 1993) and C. grandis, C. marginata, C. obtusifolia, C. occidentalis and C. siamea (Pant et al., 1974).

The contents of copper, zinc and manganese of all the three germplasm seed materials of Cassia obtusifolia appear to be higher when compared with the contents of copper, zinc and manganese in Cassia laevigata (Siddhuraju et al., 1995c) and C. obtusifolia (Mohan and Janardhanan, 1995c). Among the three, Courtallum germplasm registers the highest content of copper (2.06 mg 100g⁻¹ seed flour); Topslip germplasm registers the highest content of zinc (30.04 mg 100g⁻¹ seed flour) and Courtallum germplasm registers the highest content of manganese (4.15 mg 100g⁻¹ seed flour).

All the three germplasm seed materials of Mucuna monosperma are found to contain more sodium content compared to that of wild/tribal pulses such as Mucuna atropurpurea (Mohan and Janardhanan, 1994e); M. gigantea (Rajaram and Janardhanan, 1991a); M. hirsuta (Rajaram and
Janardhanan, 1992c) and *M. pruriens* (Sidduraju et al., 1996b). Among the three, Bagalthode germplasm exhibits the highest content of sodium (98.41 mg 100g⁻¹ seed flour). This value seems to be higher than that of *M. monosperma* (Kerala germplasm) (Arulmozhi and Janardhanan, 1992).

The potassium content of all the three germplasm seed materials of *Mucuna monosperma* appears to be higher compared to that of *Acacia nilotica* (Terry et al., 1992) and *Prosopis julifolia* (Marangoni and Alii, 1988). Among the three, Chitoor germplasm registers the highest level of potassium (681.63 mg 100g⁻¹ seed flour).

The calcium and magnesium contents of all the three germplasm seed materials of *Mucuna monosperma* are found to be higher compared to that of wild / tribal pulses such as *Mucuna atropurpurea* (Mohan and Janardhanan, 1994e); *M. monosperma* (Mohan and Janardhanan, 1995b) and *M. pruriens* (Sidduraju et al., 1996b). Among the three, Chitoor germplasm exhibits the highest content of calcium (471.05 mg 100g⁻¹ seed flour) and Borra village germplasm registers the highest content of magnesium (339.52 mg 100g⁻¹ seed flour).

All the three germplasm seed materials of *Mucuna monosperma* of the present study are found to contain more phosphorus content than two other germplasm of *Mucuna monosperma* (Mohan and Janardhanan, 1995b). Among the three, Borra village germplasm registers the highest content of phosphorus (247.57 mg 100g⁻¹ seed flour). This value seems to be higher compared to that of *Mucuna gigantea* (Rajaram and Janardhanan, 1991a) and *M. monosperma* (Arulmozhi and Janardhanan, 1992).

Among all the three germplasm seed materials of *Mucuna monosperma*, the Chitoor germplasm exhibits the highest levels of iron (10.51 mg 100g⁻¹ seed flour), zinc (12.74 mg 100g⁻¹ seed flour) and manganese (2.32 mg 100g⁻¹ seed flour). The contents of iron and zinc of this germplasm seem to be higher compared to that of iron and zinc levels of *Mucuna gigantea* (Rajaram and Janardhanan, 1991a) and *M. pruriens* (Mary Josephine and Janardhanan, 1992; Sidduraju et al., 1996b) and the manganese level seems to be higher compared to that of *M. monosperma* (Kerala germplasm) (Arulmozhi and Janardhanan, 1992) and *M. pruriens* (Sidduraju et al., 1996b).

Among all the three germplasm seed materials of *Mucuna monosperma*, the Borra village germplasm registers the highest level of copper (0.38 mg 100g⁻¹ seed flour). This value seems to be higher compared to that of *Mucuna monosperma* (Kerala germplasm) (Arulmozhi and Janardhanan, 1992).
All the three germplasm seed materials of *Mucuna pruriens* and *M. pruriens* var. *utilis* are found to contain higher levels of sodium element compared to that of wild/tribal pulses such as *Mucuna atropurpurea* (Rajaram and Janardhanan, 1992c; Mohan and Janardhanan, 1994a); *M. gigantea* (Rajaram and Janardhanan, 1991a); *M. hirsuta* (Rajaram and Janardhanan, 1992c) and *M. pruriens* (Mary Josephine and Janardhanan, 1992; Siddhuraju et al., 1996b). Among the three, Karwar germplasm of *M. pruriens* registers the highest level of sodium (107.71 mg 100g⁻¹ seed flour) and Keriparai (black-coloured seed coat) germplasm of *M. pruriens* var. *utilis* registers the highest level of sodium (150.13 mg 100g⁻¹ seed flour).

Among the three germplasm seed materials of *Mucuna pruriens*, the Aliyar germplasm registers the highest level of potassium (1587.96 mg 100g⁻¹ seed flour). This level of potassium appears to be higher compared to that of *Mucuna monosperma* (Arulmozhi and Janardhanan, 1992) and *M. pruriens* (Siddhuraju et al., 1996b).

All the three germplasm seed materials of *Mucuna pruriens* are found to contain higher levels of calcium element compared to that of earlier reports in the same species (Rajyalakshmi and Geervani, 1994; Siddhuraju et al., 1996b). Among the three, Aliyar germplasm registers the highest level of calcium (780.05 mg 100g⁻¹ seed flour). This value seems to be higher compared to that of *Mucuna gigantea* (Rajaram and Janardhanan, 1991a) and *M. utilis* (Mohan and Janardhanan, 1995b).

Among all the three germplasm seed materials of *Mucuna pruriens*, the Karwar germplasm registers the highest content of magnesium (241.28 mg 100g⁻¹ seed flour). This value seems to be higher compared to that of *Mucuna monosperma* (Mohan and Janardhanan, 1995b) and *M. pruriens* (Mary Josephine and Janardhanan, 1992; Siddhuraju et al., 1996b).

Among all the three germplasm seed materials of *Mucuna pruriens*, the Aliyar germplasm registers the highest level of phosphorus (633.79 mg 100g⁻¹ seed flour). This level appears to be higher than that of different species of the same genus reported from our laboratory (Rajaram and Janardhanan, 1991a; Arulmozhi and Janardhanan, 1992; Mohan and Janardhanan, 1994a; 1995b; Siddhuraju et al. 1996b).

All the three germplasm seed materials of *Mucuna pruriens* are found to contain higher levels of iron compared to that of wild/tribal pulses such as *Mucuna atropurpurea* (Rajaram and Janardhanan, 1992c; Mohan and Janardhanan, 1994a); *M. gigantea* (Rajaram and Janardhanan, 1991a); *M. monosperma* (Arulmozhi and Janardhanan, 1992; Mohan and Janardhanan, 1995b); *M. pruriens* (Mary Josephine and Janardhanan, 1992; Rajyalakshmi and Geervani, 1994; Siddhuraju et al. 1996b).
Among the three germplasm seed materials of *Mucuna pruriens*, the Arunooli germplasm registers the highest level of copper (0.98 mg 100 g\(^{-1}\) seed flour). This value appears to be higher compared to that of *Mucuna monosperma* and *M. utilis* (Mohan and Janardhanan, 1995b) and *M. pruriens* (Mary Josephine and Janardhanan, 1992).

Among the three germplasm seed materials of *Mucuna pruriens*, the Karwar germplasm exhibits the highest level of zinc (2.63 mg 100 g\(^{-1}\) seed flour). This level seems to be higher compared to that of earlier reports in the same species (Mary Josephine and Janardhanan, 1992; Siddhuraju et al., 1996b).

The manganese content in all the investigated three germplasm seed materials of *Mucuna pruriens* appears to be higher compared to that of *M. pruriens* (Siddhuraju et al., 1996b). Among the three, Arunooli germplasm exhibits the highest level of manganese (1.78 mg 100 g\(^{-1}\) seed flour).

In the present investigation, among the three germplasm seed materials of *Mucuna pruriens* var. *utilis*, the Thachenmalai (white-coloured seed coat) germplasm registers the highest levels of potassium (1722.43 mg 100 g\(^{-1}\) seed flour) and calcium (717.70 mg 100 g\(^{-1}\) seed flour). The levels of potassium and calcium of this germplasm seem to be higher compared to that of *Mucuna monosperma* (Arulmozhi and Janardhanan, 1992) and *M. pruriens* (Siddhuraju et al., 1996b).

Among the three germplasm seed materials of *Mucuna pruriens* var. *utilis*, the Thachenmalai (white-coloured seed coat) germplasm registers the highest levels of magnesium (387.56 mg 100 g\(^{-1}\) seed flour) and phosphorus (592.10 mg 100 g\(^{-1}\) seed flour). The magnesium and phosphorus levels of this germplasm seem to be higher compared to that of some wild / tribal pulses such as *Mucuna atropurpurea* (Rajaram and Janardhanan, 1992c; Mohan and Janardhanan, 1994e); *M. hirsuta* (Rajaram and Janardhanan, 1992c) and *M. monosperma* and *M. utilis* (Mohan and Janardhanan, 1995b).

Iron content of all the three germplasm seed materials of *Mucuna pruriens* var. *utilis* seems to be higher than the previous findings in different species of the genus, *Mucuna* (Rajaram and Janardhanan, 1991a; 1992c; Arulmozhi and Janardhanan, 1992; Mary Josephine and Janardhanan, 1992; Rajyalakshmi and Geervani, 1994; Mohan and Janardhanan, 1994e; 1995b; Siddhuraju et al., 1996b). Among the three, Keriparai (black-coloured seed coat) germplasm exhibits the highest level of iron content (15.01 mg 100 g\(^{-1}\) seed flour).
The contents of copper and zinc reported in all the three germplasm seed materials of *Mucuna pruriens* var. *utilis* are higher than the previous study in the same pulse (Mohan and Janardhanan, 1995b). Among the three, Thachenmalai (white-coloured seed coat) germplasm registers the highest levels of copper (2.15 mg 100g\(^{-1}\) seed flour) and zinc (7.53 mg 100g\(^{-1}\) seed flour).

Manganese content of all the three germplasm seed materials of *Mucuna pruriens* var. *utilis* seems to be higher compared to that of *Mucuna gigantea* (Rajaram and Janardhanan, 1991a); *M. monosperma* (Arulmozhi and Janardhanan, 1992) and *M. pruriens* (Mary Josephine and Janardhanan, 1992; Siddhuraju et al., 1996b). The Thachenmalai (white-coloured seed coat) germplasm exhibits the highest level of manganese (4.31 mg 100g\(^{-1}\) seed flour) content among the three germplasm presently investigated.

In general, all the different species/germplasm seed materials of the present study are found to contain higher level of sodium when compared with the values of common legumes such as *Cicer arietinum*, *Phaseolus vulgaris*, *Pisum sativum* and *Vigna unguiculata* (Meiners et al., 1976b); higher potassium content compared to *Vigna unguiculata* (Akinyele, 1989); higher calcium content compared to *Cajanus cajan* (Sankara Rao and Deosthale, 1981; Nwokolo, 1967; Kumar et al., 1991; Rajyalakshmi and Geervani, 1994), *Cicer arietinum* (Meiners et al., 1976b; Sankara Rao and Deosthale, 1981; Singh et al., 1991; Attia et al., 1994a; Pushpanjali and Khokhar, 1995), *Glycine max* (Ologhobo and Fetuga, 1984; Pushpanjali and Khokhar, 1995), *Phaseolus vulgaris* (Sangha et al., 1994; Barampama and Simard, 1995), *Vicia faba* (Youssef et al., 1987; Rani and Hira, 1993; Khalil and Mansour, 1995), *Vigna mungo* (Sankara Rao and Deosthale, 1981; Rajyalakshmi and Geervani, 1994), *V. radiata* (Sankara Rao and Deosthale, 1981; Sharma et al., 1991) and *V. unguiculata* (Meiners et al., 1976b; Akinyele, 1989); higher magnesium content compared to *V. unguiculata* (Akinyele, 1989) and iron content compared to *Cajanus cajan* (Sankara Rao and Deosthale, 1981; Udayasekharra Rao and Deosthale, 1983).

In the present investigation, except the germplasm of *Mucuna monosperma* (Chittoor and Bogalithode), *M. pruriens* (Arunooli) and *M. pruriens* var. *utilis* (Valanad), all the other species/germplasm seed materials are found to contain higher level of phosphorus content compared to that of *Cicer arietinum* var. Giza 1 and Giza 2-L (Attia et al., 1994a).

Among all the different species/germplasm seed materials presently reported, the germplasm of *Cassia obtusifolia* (three germplasm), *Mucuna pruriens* (Arunooli) and *M. pruriens* var. *utilis* (Valanad
and Thachenmalai) are found to contain higher copper content compared to *Cicer arietinum* (Pushpanjali and Khokhar, 1995).

The zinc content of all different species/germplasm seed materials, except *Cassia floribunda* (three germplasm) and *Mucuna pruriens* (Aliyar), appears to be higher compared to that of *Pisum sativum* (Meiners et al., 1976b).

In the present study, significant differences are observed among the germplasm of the same species for all investigated minerals. Such variations in the contents of minerals for the same legume species may be related to location and the level of soil fertility. Similar observation has been reported earlier (Dodd and Pushpamma, 1980).

When compared with RDA's of NRC/NAS (1980), all the species/germplasm seed materials are deficient in sodium content. The germplasm seed materials of *Canavalia gladiata* (Courtallum), *Cassia obtusifolia* (Topslip), *Mucuna pruriens* (Aliyar) and *M. pruriens* var. *utilis* (Keriparai and Valanad) are found to contain more than adequate level of potassium compared to RDA's of infants and children's (NRC/NAS, 1980).

In the present study, all the species/germplasm seed materials, except *Cassia obtusifolia* (Courtallum), *Mucuna pruriens* (Aliyar) and *M. pruriens* var. *utilis* (Keriparai and Thachenmalai), seems to be deficient in calcium content compared to RDA's of infants (NRC/NAS, 1989).

All the species/germplasm seed materials, except *Mucuna pruriens* (Aliyar), are found to contain higher magnesium content than that of infants and children's RDA's of NRC/NAS (1989).

The phosphorus content of all the species/germplasm, except *Canavalia ensiformis* (Pathanamthetta), *C. gladiata* (Courtallum, Hogenekkal and Kumiza), *Cassia floribunda* (three germplasm), *C. obtusifolia* (three germplasm), *Mucuna pruriens* (Aliyar and Karwar) and *M. pruriens* var. *utilis* (Keriparai and Thachenmalai), are deficient compared to RDA's of adults in Indian's (ICMR, 1992).

All the different species/germplasm seed materials of the present study are deficient in iron content compared to adolescent's RDA's of Indian's (ICMR, 1992). Nonetheless, the iron content of the germplasm of *Canavalia gladiata* (Courtallum and Hogenekkal), *Cassia obtusifolia* (Courtallum), *Mucuna monosperma* (Chitoor), *M. pruriens* (three germplasm) and *M. pruriens* var. *utilis* (three germplasm) appears to be higher when compared with RDA's of infants and children's (NRC/NAS, 1989).
In the present study, all the species/germplasm, except *Canavalia gladiata* (Courtallum, Paramangalam and Kumiza), *C. obtusifolia* (three germplasm), *Mucuna pruriens* (Aliyar and Arunooli) and *M. pruriens* var. *utilis* (three germplasm), are deficient in copper content compared to ESADDI of infants (NRC/NAS, 1989).

The zinc content of all the species/germplasm, except *Cassia obtusifolia* (three germplasm) and *Mucuna monosperma* (Chittoor), appears to be deficient when compared with children’s RDA’s of NRC/NAS (1983).

The germplasm seed materials of *Canavalia gladiata* (four germplasm), *Cassia floribunda* (Erattupattai), *C. obtusifolia* (three germplasm), *Mucuna monosperma* (Chittoor and Bogalthode), *M. pruriens* (Aliyar and Arunooli) and *M. pruriens* var. *utilis* (three germplasm) are found to contain higher range of manganese content compared to ESADDI of infants (NRC/NAS, 1989).

For easy comparison, the RDA’s and ESADDI values of NRC/NAS (1980; 1989) are tabulated below (Tables III and IV).

### Table III Recommended Dietary Allowances of Minerals

<table>
<thead>
<tr>
<th>Category a)</th>
<th>Age (years) a)</th>
<th>Weight (kg)</th>
<th>Height (cm)</th>
<th>Na (mg)</th>
<th>K (mg)</th>
<th>Ca (mg)</th>
<th>Mg (mg)</th>
<th>P (mg)</th>
<th>Fe (mg)</th>
<th>Zn (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants</td>
<td>0-0.5</td>
<td>6</td>
<td>60</td>
<td>-</td>
<td>-</td>
<td>400</td>
<td>40</td>
<td>300</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>0.5-1.0</td>
<td>9</td>
<td>71</td>
<td>500</td>
<td>1100</td>
<td>600</td>
<td>60</td>
<td>500</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Children</td>
<td>1-3</td>
<td>13</td>
<td>90</td>
<td>-</td>
<td>-</td>
<td>800</td>
<td>80</td>
<td>800</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>4-6</td>
<td>20</td>
<td>112</td>
<td>900</td>
<td>1550</td>
<td>800</td>
<td>120</td>
<td>800</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>28</td>
<td>132</td>
<td>-</td>
<td>-</td>
<td>800</td>
<td>170</td>
<td>800</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Males</td>
<td>11-14</td>
<td>45</td>
<td>157</td>
<td>-</td>
<td>-</td>
<td>1200</td>
<td>270</td>
<td>1200</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>15-18</td>
<td>66</td>
<td>176</td>
<td>-</td>
<td>-</td>
<td>1200</td>
<td>400</td>
<td>1200</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>72</td>
<td>177</td>
<td>-</td>
<td>-</td>
<td>1200</td>
<td>350</td>
<td>1200</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>79</td>
<td>176</td>
<td>-</td>
<td>-</td>
<td>800</td>
<td>350</td>
<td>800</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>51 +</td>
<td>77</td>
<td>173</td>
<td>-</td>
<td>-</td>
<td>800</td>
<td>350</td>
<td>800</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Females</td>
<td>11-14</td>
<td>46</td>
<td>157</td>
<td>-</td>
<td>-</td>
<td>1200</td>
<td>280</td>
<td>1200</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>15-18</td>
<td>55</td>
<td>163</td>
<td>-</td>
<td>-</td>
<td>1200</td>
<td>300</td>
<td>1200</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>58</td>
<td>164</td>
<td>-</td>
<td>-</td>
<td>1200</td>
<td>280</td>
<td>1200</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>25-50</td>
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<td>163</td>
<td>-</td>
<td>-</td>
<td>800</td>
<td>280</td>
<td>800</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>51 +</td>
<td>65</td>
<td>160</td>
<td>-</td>
<td>-</td>
<td>800</td>
<td>280</td>
<td>800</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Pregnant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1200</td>
<td>320</td>
<td>1200</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>Lactating</td>
<td>1st 6 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1200</td>
<td>355</td>
<td>1200</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>2nd 6 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1200</td>
<td>340</td>
<td>1200</td>
<td>15</td>
<td>16</td>
</tr>
</tbody>
</table>

Source: a - NRC/NAS - 1989  
       b - NRC/NAS - 1980
Table IV Estimated Safe and Adequate Daily Dietary Intakes of Minerals

<table>
<thead>
<tr>
<th>Category</th>
<th>Age (years)</th>
<th>Cu (mg)</th>
<th>Mn (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants</td>
<td>0.0 - 0.5</td>
<td>0.4 - 0.6</td>
<td>0.3 - 0.6</td>
</tr>
<tr>
<td></td>
<td>0.5 - 1.0</td>
<td>0.6 - 0.7</td>
<td>0.6 - 1.0</td>
</tr>
<tr>
<td>Children</td>
<td>1 - 3</td>
<td>0.7 - 1.0</td>
<td>1.0 - 1.5</td>
</tr>
<tr>
<td>and</td>
<td>4 - 6</td>
<td>1.0 - 1.5</td>
<td>1.5 - 2.0</td>
</tr>
<tr>
<td>adolescents</td>
<td>7 - 10</td>
<td>1.0 - 2.0</td>
<td>2.0 - 3.0</td>
</tr>
<tr>
<td></td>
<td>11 +</td>
<td>1.5 - 2.5</td>
<td>2.0 - 5.0</td>
</tr>
<tr>
<td>Adults</td>
<td>1.5 - 3.0</td>
<td>2.0 - 5.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: NRC/NAS - 1989

5.5 In vitro protein digestibility (IVPD)

For several thousand years, man has focused his attention on legumes and cereals which have become of great importance to satisfy his alimentary needs. With a higher protein contents, along with energy levels and the important vitamin and mineral contents, legumes have been recognized for their nutritional importance (Sotelo et al., 1995a). Legume seeds contain about 2-3 times more protein compared with cereals, but the protein digestibility is very poor (Liener, 1962). Besides the problem of sulphur amino acid deficiency of legume seeds, the more efficient utilization of proteins from legume seed meal is dependent on protein digestibility.

There is a big reservoir of proteins in the wild legumes, whose consumption is limited by the presence of antinutritional factors (Sotelo et al., 1995a). Antinutritional factors like protease inhibitors (Liener and Kakade, 1980), phytate (Oberleas, 1983), lectins (Liener, 1974), polyphenols (Elias et al., 1979) and others adversely affect the protein digestibility.

There is considerable variation in protein digestibility not only between species but also within the same species (Bressani et al., 1982; Laurena et al., 1991; Chitra et al., 1995). This variation could be due to the variations in protein fractions and levels of protein inhibitors present in the varieties (Prathiba and Uma Reddy, 1994).
The IVPD of tribal pulses (Tables 37-39) recorded in the present study is much less than that reported for casein (97.7%) (Acton et al., 1982).

The data on IVPD of proteins of raw seeds of all the germplasm of Canavalia ensiformis show relatively closer and higher values of protein digestibility compared to an earlier report in several Philippine indigenous Canavalia ensiformis (Laurena et al., 1991). Among the four, Maananthavaadi (maroon-coloured seed coat) germplasm exhibits the highest percentage of protein digestibility (79.18%).

Among the four germplasm seed materials of Canavalia gladiata, both the white-coloured seed coat germplasm exhibit more protein digestibility (74.66 and 76.92%) compared to both the maroon-coloured seed coat germplasm (63.39 and 70.16%). Due to the presence of relatively high contents of total free phenolics, tannins and trypsin inhibitor, the maroon-coloured seed coat germplasm of C. gladiata exhibits low level of IVPD compared to white-coloured seed coat germplasm. Both the white-coloured seed coat germplasm of C. gladiata exhibit high levels of IVPD compared to the two Philippine indigenous varieties of C. gladiata (Laurena et al., 1991).

In general, studies on IVPD for Cassia species / germplasm are meagre (Sidduraju et al., 1995c). Therefore, the present investigation on IVPD for three germplasm seed materials each of Cassia floribunda and C. obtusifolia is first of its kind. Between the two species of Cassia, the three germplasm of C. floribunda register the higher values of IVPD (81.44-85.94%) compared to the three germplasm of C. obtusifolia (74.66-76.92%).

All the three germplasm seed materials of Mucuna monosperma exhibit higher levels of protein digestibility compared to the earlier reports in Mucuna pruriens, Phaseolus lunatus and Vigna umbellata (Laurena et al., 1991). Among the three, Chittoor germplasm registers the highest level of protein digestibility (85.94%) and it is in consonance with an earlier report in Vigna umbellata var. ACC 28 (Rodriguez and Mendoza, 1991).

Three germplasm of Mucuna pruriens studied, show that, the seeds of Aliyar germplasm exhibit the highest percentage of protein digestibility (74.66%) compared to the other two germplasm. This value appears to be higher than an earlier report in Mucuna pruriens (Laurena et al., 1991).

Among the three germplasm seed materials of Mucuna pruriens var. utilis presently reported, the white-coloured seed coat (Thachenmalai) germplasm registers the highest level of protein digestibility (76.92%) compared to the two black-coloured seed coat germplasm. The high levels of trypsin inhibitor activity in the two black-coloured seed coat germplasm might be attributed for the low
protein digestibility values. The IVPD percentage of Thachenmalai germplasm appears to be higher than an earlier report in *Mucuna utilis* (Ravindran and Ravindran, 1988).

The relatively low levels of IVPD in legume seeds are due to the presence of globulins as the major storage proteins which are quite resistant to the attack by proteolytic enzymes *in vitro* (Liener and Thompson, 1980; Deshpande et al., 1982; Sathe et al., 1994). Significantly, the IVPD of presently investigated raw seeds of *Canavalia ensiformis* (four germplasm), *C. gladiata* (two white-coloured seed coat), *Cassia floribunda* (three germplasm), *C. obtusifolia* (three germplasm), *Mucuna monosperma* (three germplasm), *M. pruriens* (Aliyar) and *M. pruriens var. utilis* (Thachenmalai, white-coloured seed coat) seems to be higher compared to cultivated legumes such as *Arachis hypogaea* (Prathiba and Uma Reddy, 1994); *Cajanus cajan* (Jambunathan and Singh, 1981a; Rajyalakshmi and Geervani, 1990); *Cicer arietinum* (Srivastav et al., 1990; Attia et al., 1994a); *Glycine max* (Srivastav et al., 1990); *Phaseolus vulgaris* (Deshpande et al., 1982); *Pisum sativum* (Rajyalakshmi and Geervani, 1990; Bishnoi and Khetarpaul, 1994a; Saharan and Khetarpaul, 1994); *Vigna mungo* and *V. radiata* (Chitra et al., 1995) and *V. unguiculata* (Laurena et al., 1986; Rajyalakshmi and Geervani, 1990).

Domestic processing, germination and dehulling of pulses significantly lowered phytic acid, saponin, polyphenols, protease inhibitors and lectins and improved IVPD in cultivated legumes (Kataria et al., 1989a; Srivastav et al., 1990; Attia et al., 1994a; Bishnoi and Khetarpaul, 1994a) and also in tribal pulses (Vijayakumari et al., 1995; 1997b).

### 5.6 Antinutritional factors

The usefulness of legumes is reduced since their concentrated protein is associated with antinutritional substances (Aletor and Fetuga, 1984; Egbe and Akinyele, 1990; Liener, 1994).

The antinutritional factors include protease inhibitors, phytate, lectins, tannins, cyanogenic glucosides, alkaloids, non-protein amino acids, flatulence factors, saponins and allergins (Liener, 1994). Antinutritional factors in legume seeds adversely affect the protein digestibility (Gupta, 1987). These substance unless destroyed by heat or some other suitable treatment can exert adverse physiological effects when ingested by man and animals (Liener, 1980). On the contrary, it has been suggested that consumption of low levels of certain antinutrients may produce health benefits while avoiding some of the adverse effects associated with their large intake (Thompson, 1988).

#### 5.6.1 Total free phenolics and tannins

Polyphenols are present in almost all plant parts and they are common in most plant foods (Bravo et al., 1994).
Polyphenols have different effects in the intestine depending on their solubilities. Extractable polyphenols appear to be absorbed from the digestive tract and produce systemic effects, such as reduction of the metabolic utilization of absorbed amino acids and elevated plasma levels of growth hormone (Martin-Tanguy et al., 1976; Barry et al., 1986). Non-extractable polyphenols are not absorbed in the intestine and are recovered quantitatively in faeces (Bravo et al., 1992; 1993).

Phenolic compounds inhibit the activity of digestive as well as hydrolytic enzymes such as α-amylase, trypsin, chymotrypsin and lipase (Salunkhe et al., 1982b). Polyphenols decrease the digestibility of carbohydrates and the availability of vitamins and minerals (Udayasekhara Rao and Deosthale, 1982) and interact with protein to make them insoluble (Singh, 1984).

The contents of total free phenolics in red-coloured seed coat germplasm of Canavalia ensiformis seem to be relatively higher than maroon-coloured seed coat germplasm. Among the four, Valacode (red-coloured seed coat) germplasm registers the highest content of total free phenolics (1.23%), which is comparable to that of an earlier report in the same legume (Rajaram and Janardhanan, 1992b). The content of tannins in all the four germplasm seed materials of C. ensiformis seems to be lower than an earlier study in the same species (Rajaram and Janardhanan, 1992b).

The levels of both phenolics and tannins in maroon-coloured seed coat germplasm seed materials seem to be relatively higher than that of white-coloured seed coat germplasm seed materials of Canavalia gladiata. Among the four, Paramangalam (maroon-coloured seed coat) germplasm exhibits the highest percentage of phenolics (2.55%) and tannins (0.57%). These levels seem to be higher compared to earlier studies in C. gladiata (Rajaram and Janardhanan, 1992b; Mohan and Janardhanan, 1994c).

All the three germplasm seed materials of Cassia floribunda are found to contain lower level of total free phenolics and higher tannin content compared to an earlier study in Cassia floribunda (Janardhanan, 1993).

The contents of total free phenolics and tannins in all the three germplasm seed materials of Cassia obtusifolia appear to be higher than an earlier study in the same species (Vijayakumari et al., 1993b). Nonetheless, the three germplasm seed materials of the present study are found to contain lower levels of phenolics and tannins than that of Cassia laevigata (Siddhuraju et al., 1995c).

All the three germplasm seed materials of Mucuna monosperma are found to contain lower levels of phenolics than Mucuna pruriens (Siddhuraju et al., 1996b) and lower level of tannin than
Mucuna gigantea (Rajaram and Janardhanan, 1991a) and M. atropurpurea and M. hirsuta (Rajaram and Janardhanan, 1992c).

The levels of both phenolics and tannins in all the three germplasm seed materials of Mucuna pruriens and M. pruriens var. utilis appear to be lower compared to previous studies in Mucuna pruriens (Siddhuraju et al., 1996b; Vijayakumari et al., 1996).

In general, in the present study, the germplasm seed materials of Canavalia ensiformis (red-coloured seed coat), C. gladiata (maroon-coloured seed coat), Mucuna monosperma (three germplasm), M. pruriens (three germplasm) and M. pruriens var. utilis (three germplasm) exhibit high levels of total free phenolics compared to other species/germplasm seed materials.

All the different species/germplasm seed materials of the present study are found to contain lower levels of tannin content than that of some cultivated legumes like Glycine max, Phaseolus vulgaris, Vigna radiata and V. unguiculata (Mnembuka and Eggum, 1995) and V. radiata and V. mungo (Malhotra et al., 1988).

The tannins and phenolics are water soluble compounds (Uzogara et al., 1990) and they can be eliminated by decortication, soaking and heat treatment or cooking process (Singh, 1988; 1993; Kataria et al., 1989a; Singh and Singh, 1992).

It seems that polyphenols may not pose a serious problem particularly to people in regions where pulses are consumed after decortication. Soaking (water discard) followed by cooking before consumption is suggested as a means of removing harmful effects of polyphenolic compounds in the regions where pulses are consumed as whole seeds (Udayasekhararao and Deosthale, 1982).

Improvement of the protein digestibility by reducing the levels of total free phenolics and tannins has been well documented in some tribal pulses (Siddhuraju et al., 1996a,b; Vijayakumari et al., 1995; 1996; 1997a,b).

5.6.2 L-DOPA (3,4-dihydroxyphenylalanine)

The Valacode (red-coloured seed coat) germplasm of Canavalia ensiformis exhibits the highest level of L-DOPA among the four germplasm presently investigated (2.64%). This value is found to be more or less equal to that of an earlier report in Canavalia ensiformis (Mohan and Janardhanan, 1994c).

All the four germplasm seed materials of Canavalia gladiata seem to contain low contents of L-DOPA compared to an earlier report in the same species (Mohan and Janardhanan, 1994c). Among
the four germplasm presently studied, the Courtallum (maroon- coloured seed coat) germplasm registers the highest percentage of L-DOPA (2.83%).

In general, maroon-coloured seed coat germplasm seed materials of Canavalia ensiformis and white-coloured seed coat germplasm seed materials of C. gladiata are found to contain less amounts of L-DOPA compared to that of red-coloured seed coat germplasm of C. ensiformis and maroon-coloured seed coat germplasm C. gladiata, respectively.

All the three germplasm seed materials of Cassia floribunda and C. obtusifolia are found to contain lower levels of L-DOPA content than that of an earlier study in Cassia obtusifolia (Mohan and Janardhanan, 1995c).

Among the three germplasm seed materials of Mucuna monosperma, the Bogalthode germplasm exhibits the highest L-DOPA content (4.52%). This value seems to be more or less equal to that of an earlier investigation in Mucuna monosperma (Kerala germplasm) (Arulmozhi and Janardhanan, 1992).

The content of L-DOPA in all the three germplasm seed materials of Mucuna pruriens is found to be low when compared with an earlier study in the same species (Vijayakumari et al., 1996).

Among the three germplasm seed materials of Mucuna pruriens var. utilis, the Keriparai (black-coloured seed coat) germplasm registers the highest content of L-DOPA (6.78%). This value is found to be lower than the previous reports of our laboratory (Rajaram and Janardhanan, 1992c; Mary Josephine and Janardhanan, 1992; Siddhuraju et al., 1996b; Vijayakumari et al., 1996). In the present study, white-coloured seed coat germplasm (Thachenmalai) of M. pruriens var. utilis is found to contain lower levels of L-DOPA than black-coloured seed coat germplasm. This is in agreement with an earlier report in the same species (Mohan and Janardhanan, 1995b).

In an earlier study, it has been demonstrated that the level of L-DOPA gets significantly reduced by repeated soaking and boiling of seeds (Jebadhas, 1980). Longo et al. (1974) and Larher et al. (1984) also observed the loss of L-DOPA during the drying of plant samples. Janardhanan (1982) has demonstrated that repeated boiling of seeds in water and decanting of the water for seven times resulted in a substantial reduction in the quantity of L-DOPA. Further, such processed seeds have been shown to be safe for consumption among the consuming tribals. Recently, Siddhuraju et al. (1996b) reported that dry heat treatment also has been found to be more effective in reducing the L-DOPA content.
5.6.3 Trypsin inhibitor activity

In legume seeds protease inhibitors are widely distributed and differ in specificity and potency of inhibition which depends on the origin of the target enzyme (Birk, 1989).

Inactivation of trypsin in the gut by trypsin inhibitors from soybeans induces the intestinal mucosa to release cholecytokinin. This hormone stimulates pancreas acinar cells to produce more trypsin, chymotrypsin, elastase and amylase. When this negative feedback continues, an important loss of S-containing amino acids is created. This leads to a depression in growth, pancreatic hypertrophy / hyperplasia and carcinogenic effects (Liener, 1989b). Trypsin inhibitors from other legumes depress growth and cause pancreatic hypertrophy in much the same way as the soybean inhibitors (Liener and Kakade, 1980). A large variation in occurrence of trypsin inhibitor has been reported in chickpea and pigeonpea (Singh, 1988).

Among the four germplasm seed materials of *Canavalia ensiformis* and *C. gladiata*, Valacode germplasm of *C. ensiformis* (red-coloured seed coat) and Courtallum germplasm of *C. gladiata* (maroon-coloured seed coat) exhibit the highest trypsin inhibitor activity (34.34 and 26.83 TIU/mg protein, respectively) compared to other germplasm of the same species. Interestingly, these values are found to be lower than that of the values recorded for some cultivated legumes such as *Arachis hypogaea* and *Cicer arietinum* (Hira and Chopra, 1995); *Cajanus cajan* (Jambunathan and Singh, 1981a) and *Vicia faba* (Rani and Hira, 1983). In general, the maroon-coloured seed coat germplasm of *C. ensiformis* and white-coloured seed coat germplasm of *C. gladiata* are found to contain lower levels of trypsin inhibitor activity than that of red-coloured seed coat germplasm of *C. ensiformis* and maroon-coloured seed coat germplasm of *C. gladiata*, respectively (Tables 40-43).

The trypsin inhibitor activity in all the three germplasm seed materials of *Cassia floribunda* (16.42-17.43 TIU/mg protein) and *C. obtusifolia* (12.34-13.72 TIU/mg protein) seem to be low compared to all other species/germplasm seed materials of the present study and also to an earlier study in *Cassia laevigata* (Siddhuraju et al., 1995c).

In the present study, the different species of *Mucuna* germplasm are found to contain higher trypsin inhibitor activity than that of *Canavalia* and *Cassia* species / germplasm. The *Mucuna* species such as *M. monosperma*, *M. pruriens* and *M. pruriens* var. *utilis* are found to contain trypsin inhibitor activity in the range of 62.48-68.32, 58.74-62.34 and 40.72-48.23 TIU/mg protein, respectively (Tables 46-48). The trypsin inhibitor activity of all the *Mucuna* species / germplasm of the present study are found to be lower than that of earlier studies in some wild / under-exploited / tribal pulses such as...
Atylosia albicans, A. volubilis and Rhynochosia rothii (Singh and Eggum, 1984); Bauhinia purpurea (Vijayakumari et al., 1997a); Lathyrus sativus (Ayyagari et al., 1989) and Mucuna pruriens (Siddhuraju et al., 1996b).

In general, in the present study, all the different species/germplasm seed materials are found to contain lower levels of trypsin inhibitor activity than that of Cajanus cajan var. Pant A-2 and UPAS-120 (Singh and Eggum, 1984) and Phaseolus vulgaris (Antunes and Sgarbieri, 1980).

The thermo-labile nature of legume protease inhibitors has long been known (Liener, 1976a). During germination the trypsin inhibitor activity decreases in Dolichos biflorus and Phaseolus aconitifolius (Subbulakshmi et al., 1976) and Canavalia ensiformis (Babar et al., 1988). Recently, significant reduction of trypsin inhibitor activity in some tribal pulses has been noticed when subjected to both dry heat treatment and autoclaving (Siddhuraju et al., 1996b; Vijayakumari et al., 1996; 1997a).

5.6.4 Phytohaemagglutinins (Lectins)

Lectins are proteins of nonimmune origin that recognize and reversibly bind to carbohydrate moieties of complex carbohydrates and glycoproteins without altering the covalent structure of any of the recognised glycosyl ligands (Goldstein et al., 1980). Although lectins are present in all taxonomic groups of the plant kingdom, they appear to be particularly abundant in the Leguminosae family (Strosberg et al., 1986). Seeds are the richest source of lectins, but other parts of the plants may also contain smaller amounts of lectins (Etzler, 1986). There has been a great deal of speculation on the possible role of protecting plants and among the other functions, it has been suggested that they may well serve a defensive role in protecting plants against invasion by bacteria, fungi and insects (Janzen et al., 1976; Etzler, 1986).

Lectins are toxic factors that interact with glycoprotein on the surface of red blood cells and cause them to agglutinate. Food legumes have long been known to contain protein compounds which agglutinate the red blood cells (Singh, 1988). The biological effects of lectins such as; an impairment in transport of nutrients across the intestinal wall, intestinal hypertrophy accompanied by an increased rate of synthesis of mucosal proteins, increased catabolism of liver and muscle proteins, a lowering of blood insulin levels and an inhibition of brush border hydrolases, have been demonstrated (Liener, 1986; Pusztai, 1987). Lectins combine with the cells that line the intestinal mucosa and cause a non-specific interferene with the absorbtion of available nutrients (Liener, 1994).

The present study reveals that both albumins and globulins of all the germplasm seed proteins of Canavalia ensiformis, C. gladiata, Cassia floribunda, C. obtusifolia, Mucuna pruriens and M. pruriens
var. *utilis* agglutinate the human blood erythrocytes without any specificity against the "ABO" system. In general, the globulins exhibit strong agglutinating activity compared to the albumin fraction. This observation is in consonance with the earlier reports from our laboratory in tribal pulses like *Abrus precatorius* (Rajaram and Janardhanan, 1992a); *Entada scandens* (Vijayakumari et al., 1993b); *Mucuna monosperma* and *M. utilis* (Mohan and Janardhanan, 1995b); *Parkia roxburghii* (Mohan and Janardhanan, 1993a); *Vigna capensis* and *V. sinensis* (Mohan and Janardhanan, 1993b) and *V. umbellata* (Mohan and Janardhanan, 1994d).

The albumins of *Mucuna monosperma* germplasm do not exhibit haemagglutinating activity, whereas globulins show weak haemagglutination. This is in agreement with some earlier observations in *Bauhinia malabarica* (Vijayakumari et al., 1993a); *B. racemosa* (Rajaram and Janardhanan, 1991b; Mohan and Janardhanan, 1994b); *B. tomentosa* (Mohan and Janardhanan, 1995a); *Cassia floribunda* (Janardhanan, 1993); *Mucuna monosperma* (Arulmozhi and Janardhanan, 1992); *Vigna aconitifolia* (Siddhuraju et al., 1994) and *V. trilobata* (Siddhuraju et al., 1992b).

Lectins are highly sensitive to heat treatment (Singh, 1988). The haemagglutinating activity in *Dolichos biflorus*, *Glycine max*, *Phaseolus vulgaris*, *Vicia faba* and *Vigna radiata* decrease during germination (Valdeboze et al., 1980). A significant reduction in lectin activity has been noticed when the seeds of certain tribal pulses are subjected to both dry heat treatment and autoclaving (Siddhuraju et al., 1996b; Vijayakumari et al., 1997a) and cooking and autoclaving (Vijayakumari et al., 1995; 1996).

In conclusion, there is a diversity in nutritional and antinutritional constituents among the germplasm seed materials of the same species. Selection of germplasm based on high nutritive values coupled with low antinutritional components either based on conventional breeding or novel biotechniques is suggested with a view to evolve new varieties with desirable biochemical traits.

In the present investigation, most of the germplasm seed materials exhibit fairly high levels of food constituents and *in vitro* protein digestibility when compared with certain cultivated legumes. Besides, the antinutritional factors such as trypsin inhibitors and lectins happen to be heat labile. They can be easily eliminated / reduced by ordinary culinary practices.

After conducting animal feeding experiments and toxicological evaluation, the presently studied tribal pulses may be recommended as the less expensive and the potential alternate protein sources to alleviate PEM among the economically weaker sections of population including the tribal people living in various parts of India.