ASSESSMENT OF QUALITY OF SELECTED VARIETIES OF GREEN GRAM AND GRAIN COWPEA

BY

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THESIS

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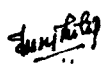
DECLARATION

I hereby declare that this thesis entitled **"Assessment of quality of selected varieties of greengram and grain cowpea"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the associateship, fellowship or other similar title of any other University or Society.



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CERTIFICATE

Certified that this thesis entitled **"Assessment of quality of selected varieties of greengram and grain cowpea"** is a record of research work done independently by **Mrs. Jessy Philip**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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INTRODUCTION

INTRODUCTION

Food Legumes or pulses, as they are commonly known, play a very important role in human diet in our country. As a source of vegetable protein it is an essential supplement to cereal based diets. Pulses are commonly consumed in combination with cereals and make good the deficiency of lysine in cereals, while cereals supply sufficient sulphur containing amino acids to supplement the deficiency in pulse protein. For countries like India, pulses combined with the cereals offer the most practical way of solving the problem of protein malnutrition. The daily intake of food legumes in the balanced diet according to recent recommendations is around 50 g. The non-availability of pulses in the international market and their expensive import has given impetus to increase their productivity per unit area and per unit time in India to meet the growing demands of pulses. Even with a moderate estimate of per capita pulse availability of 60 g/day, the projected requirements by 2000 AD will be 24 million tonnes and would require in the coming decade to almost double our pulse production in the country. In Kerala, pulses are grown in an area of 23 thousand hectares and the production is 16 thousand tonnes in 1991-92.

Considering the importance of food legumes in human health and nutrition, the present situation prevailing in the country calls for immediate and concentrate efforts to maximize the production and proper utilization of this valuable source of food. Breeding techniques are adopted for the improvement of productivity, adaptability and yield stability in grain legumes.

The importance of grain legumes as an excellent source of protein, energy, vitamins and minerals in cereal based diets is fully accepted. Several studies in animals and man have shown pulses to be effective cholesterol lowering agents. These legumes however contain certain antinutrients which hinder the efficient utilization, absorption or digestion of nutrients and thus decrease their bioavailability and their nutritional qualities.

World wide attention is needed to improve the nutritional quality of grain legumes by breeding techniques or developing suitable processing techniques. Traditional methods of processing and cooking legumes have been evolved to give safe, appetizing and nutritious products. Appropriate processing is probably more important for legumes than for any other food group, owing to the high content of toxins and the indigestible nature of many constituents. In this context, the monitoring of newly developed genotypes of grain legumes for cooking quality and various nutritional attributes and the influence of processing on these qualities has to be emphasized. Hence the present programme envisages a detailed study on the different qualities of pulse varieties and assesses the effect of different cooking treatments on the quality parameters.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The grain legumes commonly known as pulses form an important component in the diets of majority of the population of India. This crop plays an important role for correcting malnutrition in the country. Currently research is oriented towards an improvement in the yield and qualities of high yielding varieties of pulses.

The chapter presents a review of earlier studies conducted on the quality characteristics of pulses under.

2.1 Physical and cooking characteristics of pulses.

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2.6 Effect of processing and cooking on the antinutritional factors in pulses.

2.1 Physical and cooking characteristics of pulses

An attempt was made to provide information on the importance of physical characteristics and the association between the physico chemical properties and the cooking qualities of pulses. Such an information may be useful to breeders in the selection and development of pulses and to food processors attempting to overcome the problem of cookability encountered in pulses. Physical characteristics such as colour, size weight and density are factors influencing the quality of pulses. Agricultural and environmental factors and genotype influence these physical characteristics. Many of the high yielding varieties evolved in pulse crops recently have faced criticism from the consumers regarding their physical and cooking quality. This is largely because of the fact that the consumers' preference is not given importance while breeding newer varieties.

Difference in the flavour and over all quality of dry beans are associated with the colour, size and shape of the seeds which define the specific bean class as reported by Adams and Bedford (1973). According to Singh *et al.* (1990) uniformity in seed size and shape is an

important quality parameter necessary for both trade and food preparation. Large seed size and smooth seed coat are generally preferred for pulses.

Umaid Singh *et al.* (1990) has also reported that from the consumer point of view, small seeds pigeonpeas are not preferred. Conclusions drawn from the literature indicate that yield may be improved by selection based on seed size and seed size is probably controlled by more than one but a relatively small number of genes as reported by Singh *et al.* (1990).

Factors such as soil type, planting time, growing seasons, use of fertilizer, irrigation practice and other factors all affect seed size (Singh *et al.*, 1989). It is possible that environmental effects including moisture availability but particularly at ambient temperature during the seed maturation period may cause strong reaction by the genes which control seed size (Singh *et al.* (1990).

Seed weight is one of the primary yield component and it provides a limited support for selection criteria as reported by Patil *et al.* (1989).

According to Singh *et al.* (1990) parameters such as seed size which are highly heritable, may not be stable and a variability of over 50 per cent occurred with same genotypes grown at different location and seasons. Length and width of the pulses are major factors influencing seed size (Gabriel and Giovanni, 1991). They further reported that the length of cowpea cultivars may range from 0.59 to 0.89 cm and width from 0.47 to 0.63 cm.

There was positive and significant correlation between grain volume and 100 grain mass of pigeonpea genotypes (Singh *et al.*, 1992).

Study conducted by Sood *et al.* (1991) revealed that seed index, seed density and seed volume of blackgram varieties did not show considerable variability and were more or less constant.

Results of the study conducted by Singh *et al.* (1990) indicates that hundred seed weight displayed variability among sites, and marked influence of growing location and

season were also apparent. Shivashankar *et al.* (1974) studied the physical characteristics of 60 mungbean cultivars and according to their observations 100 grain weight of cultivars varied from 2.06 to 5.09 g and their volume from 1.50 to 3.88 ml. Hundred seed weight of chickpea is also reported to vary from 8.00 to 67.00 (Singh *et al.*, 1990) and that of cowpea ranged from 9.20 to 20.40 g (Gabriel and Giovanni, 1991) and of pigeonpea ranged from 9.30 to 12.70 g (Umaid Singh *et al.*, 1990). There was positive and significant correlation between grain mass of pigeonpea genotype as reported by Singh *et al.* (1992).

The physico chemical properties of cowpea cultivars were studied in detail by Sunday and Uzodema (1993) and reported that 100 seed weight of the cultivars ranged from 12.50 to 18.60 and seed volume from 62.00 to 88.00 ml. Seed density of the cultivars were in the range of 1.12 to 1.21 g/ml and leached solid were found to range from 0.33 to 0.94 per cent. Swelling capacity of the cultivars after heat application was 77.00 to 123.00 per cent.

The parameters participating in the cookability of legume seeds are numerous like size of the seeds and initial moisture content (Bhatty, 1984), cultivars and cultivation conditions, (Bhatty, 1988) swathing (Tang *et al.*, 1990), and drying rate (Tang *et al.*, 1992). Storage conditions (duration, temperature and humidity) were also reported to interfere with the hydration rate and cookability of legume seeds (Autunes and Sgarbieri, 1979). Cooking quality of legume have been shown to be affected by varietal difference (Longe, 1983) and structure and composition of seeds (Sefa - Dedeh and Stanley, 1979).

Seed weight or size, swelling capacity, seed coat per cent and seed coat texture of certain beans have been associated with their cooking quality (Akingele *et al.*, 1986). Hicks and Staley, (1987) claim that the softening of black beans during cooking is closely related to water uptake and that starch composition plays a minor role in cookability.

The physical characteristics of the seeds appeared to be important for water absorption as found by Deshpande *et al.* (1984). A higher surface area might particularly account for the higher hydration levels. Water absorption of legumes has been shown to be

influenced by seed coat structure and thickness, seed size, helium size, protein content, calcium content and initial moisture content (Sefa-Dedeh and Stanley 1979;

Hsu *et al.*, 1983). Legumes take considerably longer time for cooking than any other vegetable products. This is especially true with whole pulses. Hence the cooking time is an important factor influencing the consumer preference because of time taken and greater fuel consumed (Rosaiah *et al.*, 1993). Increase cooking time concerns people as the energy sources are becoming increasingly scarce and expensive.

Hard to cook or hard shell defect of the pulses is of importance to consumers from the point of view of convenience and the saving of valuable cooking fuel (Sunday and Uzodema 1993). Shivashankar *et al.* (1974) reported that consumers prefer the varieties which cook quickly and expands greatly in volume after cooking. A survey conducted by Umaegbute and Nnanyelugo (1987) in Nigeria revealed that cooking difficulty was the leading constraint on cowpea consumption. According to Edijala (1980) Sunday and Uzodema (1993) one of the major constraints to the expanded consumption of cowpea as well as other beans is that certain cultivars take a longer time to cook or soak than others. Cooking time depends on species and cultivar (Meiners *et al.* (1976) and Rockland *et al.*, (1979). Cooking quality of legumes have been shown to be affected by varietal difference (Longe, 1983). Sharma *et al.* (1977) identified some pigeonpea varieties requiring 20.00 to 21.50 minutes for cooking and Umaid Singh *et al.* (1993) reported 18.00 to 21.00 minutes as cooking time for various pigeonpea genotypes. Cooking time of cowpea varieties were reported to vary between 29.00 and 37.00 minutes (Sunday and Uzodema, 1993); 29.00 to 64.00 minutes (Demooy and Demooy 1990); 41.50 to 135.00 minutes (Longe 1983) and 40.00 to 220.00 minutes (Meiners *et al.*, 1976; Rockland *et al.*, 1979). Cooking time of chickpea varied from 50.00 to 296.00 minutes (Singh *et al.*, 1990).

Few physical properties such as seed size or weight, swelling capacity, seed coat percentage and seed coat texture of certain beans are also reported to be associated with their cooking quality (Deshpande *et al.*, 1984 and Akingele *et al.*, 1986). William *et al.*, (1983) reported positive correlation between seed size and cooking time for chickpea. Seed size

governs and distance to which water must penetrate inorder to reach the innermost portion of seed (Narpinder Singh *et al.*, 1992). However Umaid Singh *et al.* (1991) reported difference in cooking time of chickpea varieties which has about the same seed size. Demooy and Demooy (1990) evaluated seven cowpea varieties and reported that small seeded varieties have longer cooking time.

Singh *et al.*, (1989) reported that the effect of size on cooking time in fababean is probably influenced in part by the shape of the seed as well as by size. When different cultivars of fable beans were separated into large, medium and small seeds with in a cultivar, among the smaller seeded beans there was a higher correlation with cooking time than among larger seeds. This was attributed to the shapes of the beans-the large beans were flatter than the smaller ones and the minimum distance for water penetration inorder to effect cooking was less in the larger beans relative to size (weight) than in those of medium size. The high correlations between size and cooking time dry fababean in this study illustrate that as with chickpea and lentil, selection of fababean on the basis of size permits good prediction of cooking time. Since tests of cooking time are time consuming and labour intensive, seed weight is an adequate predictor of cooking time for selection purpose.

Cooking time was highly correlated with hundred seed weight in chickpea (Singh *et al.*, 1990) which confirmed an earlier observation of Williams *et al.*, (1983). Cooking time was affected to the same extent as hundred seed weight by growing season and location (Singh *et al.*, 1990).

Sefa - Dedeh and Stanley (1979) reported that structure and composition of seeds influence cooking time. Longer cooking time may be due to thicker seed coat and low water absorption (Narasimha and Desikachar 1978, Rosaiah *et al.*, 1993). Grains which absorb water quickly will take less time for cooking. The water absorbing capacity depends on cell wall structure, composition of seed and competence of the cells in the seeds (Muller, 1967).

De Leon *et al.* (1989) suggested that the seed coat plays a significant role in the hard to cook process of common beans before and during storage, leading to the hypothesis that

tannins may emigrate to cotyledons and react with bean components, such as protein and or carbohydrates and participate in polymerization reaction.

The results of the study conducted by Reyes-moreno *et al.* (1994) suggest a positive role of seed coat tannin content in the tendency and development of the hard to cook defect in common beans. Kon and Sanshuck (1981) reported that certain chemical components or characteristics of grain legume seeds have been implicated as affecting cooking quality. Cooking quality of beans depends on factors such as growing conditions, mineral contents, phytic acid levels and storage and handling (Pawar and Ingle 1987). Cooking time was observed to be positively related to the calcium and magnesium contents, where as iron was found in trace amounts and cooking time did not have any effect on it (Monica *et al.*, 1992).

A study conducted by Kailasapathy and Koneshan (1986) on the effect of soaking of greengram, cowpea and blackgram on cooking quality revealed a reduction in cooking time. Onayemi *et al.* (1986) reported a reduction of 23.00 to 25.00 per cent in cooking time of cowpea as a result of 9 hours presoaking treatment in water.

Soaking reduced cooking time from 267.00 to 66.00 minutes for fababean, from 103.00 to 35.00 minutes for chickpea, and from 27.00 to 9.00 minutes for lentil (Singh *et al.*, 1989).

According to Sunday and Uzodema (1993) cooking time was reduced by about 21.00 per cent following presoaking treatment in water for 12 hours at room temperature. Water absorption was not related to cooking time was much lower for the variety with larger seeds. Leached solids and swelling capacity were 0.33 to 0.94 per cent and 77.00 to 123.50 per cent reported for cowpea. (Sunday and Uzodema, 1993). According to Chavan *et al.* (1983) soak treatments of seeds resulted in decreased dispersion of solids during cooking mungbean and black bean dhal while an increase was noted in chick and pigeonpea.

2.2 Nutritional composition of pulses

Grain legumes are important sources of proteins, minerals and vitamins for millions of people in the world, particularly in the developing countries (Singh and Singh, 1992).

They are good sources of nutritionally important dietary nutrients viz; proteins minerals (iron and calcium) and vitamins (niacin and thiamine) as suggested by Rosaiah *et al.* (1993). Rao *et al.* (1988) evaluated the chemical composition of six types of the mungbean and stated that they are rich sources of polysaccharides, proteins and minerals. The nutritional quality of pulses are also reported to very depending upon the genetic and environmental factors (Thomas and Doll, 1979). Pulses are found to be rich in proteins, minerals and vitamins (Deosthale 1982 and Sood *et al.* 1991). Varietal variation in the proximate composition of pulses was reported in many studies. According to Bressani (1985) cowpea is an important source of calories and the seed contains 65 per cent carbohydrate. In greengram varieties it ranged from 62.55 to 64.55 per cent as reported by Sharma *et al.*, (1991). Chickpea contains 52.40 to 70.90 per cent total carbohydrates of which major portion is contributed by starch (Chavan *et al.*, 1986, 1994).

Pulses provide a significant amount of calories, principally from starch which typically comprises of 25.00 to 50.00 per cent of the seed weight (Salunkhe *et al.*, 1985). It has been suggested that legume starch is less digestible than that from other sources. However, starches isolated from several legumes have been shown to be highly digestible in vivo assays (Reddy *et al.*, 1984). In vitro methods give a considerably less favourable picture, but must be considered less reliable than studies with intact animals. Of greater importance is the observation that when infact legumes are given to normal or diabetic human, both glucose and insulin responses are greatly attentuated compared to the responses to more rapidly digested starch such as that from potato (Trappy *et al.*, 1986).

Protein content of legumes varied between 18.00 to 32.00 per cent as reported by Bressani and Elias (1974). The range of crude protein values of cowpea was 19.00 to 35.00 per cent as reported by Evans an Boulter (1974); Summerfield *et al.*, (1974); Ologhobo and Fetuga, (1982) and Kochhar *et al.* (1988). Seed protein content of 25.00 per cent was reported by Oyenuge (1978) and Bressani (1985). Habib (1989) and Gabriel and Giovanni (1991) reported 23.10 to 25.20 per cent and 20.68 to 28.38 per cent protein in cowpea varieties. It has been shown that proximate composition of cowpea varies, considerably according to cultivar and cultivation (Kochhar *et al.*, 1988).

In greengram varieties protein content was reported as 26.90 per cent, 20.10 to 23.91 per cent, 23.40 to 32.00 per cent, 22.00 to 26.20 per cent, 22.10 to 23.80 per cent and 20.50 to 25.90 per cent in different varieties (Rao *et al.*, 1979, Suneeta Kumari *et al.*, 1983; Gupta, 1983; Souci *et al.*, 1986; Sharma *et al.*, 1991 and Rosaiah *et al.*, 1993).

The protein content of commonly grown pea cultivars ranged between 17.90 and 24.39 per cent for whole grain samples. (Singh and Eggum, 1984). According to Williams and Singh (1987) protein content of chickpea genotypes range between 12.40 to 31.50 per cent. The protein content was close to the findings reported by Lowgen (1988) and Sgarbieri (1989) and Tezoto and Sgarbieri (1990).

Protein content of pigeon pea genotypes ranged from 23.10 to 31.10 per cent as reported by Umaid Singh *et al.* (1990).

Variation in protein content occur among and within seed lots. Factors contributing to the variations are the production environment (Soil fertility,soil moisture, temperature, disease) production practices (cropping system, population density, fertilization) and cultivars (genotypes). Normally the total production environment and the production practice have a greater influence on protein content than the cultivar according to studies by Krober *et al.* (1970).

Trung and Yoshida (1982) reported a positive association of seed size and protein content. It has been reported that pigeonpea genotypic differences are quite large, although the possibility of small environmental effects on the protein content of these could not be ruled out. The variability in the content and composition of protein and amino acid of legumes has been attributed largely to genetic factors Salunkhe *et al.*, (1985, and Koehler et al.,1987).

The effect of location and season on protein content appeared to be about equal to the genetic effect (Singh *et al.*, 1990) and compared with spring planting, winter planting decreased protein content. Protein content which is not a highly heritable characteristic can be regarded as a more stable parameter in Kabuli chickpea, since the season to season and

location to location variability in protein content was much lower (Singh *et al.*, 1990). Along with macronutrients leguminous seeds contain appreciable amounts of minerals and vitamins as well as dietary fiber (Phillips, 1993).

The ash content of the legumes were found to be in the range of 2.90 to 3.43 per cent on dry matter basis (Alka Sharma and Salil 1992).

Calcium and iron content of legumes varied from 80.00 to 100.00 and 5.00 to 10.00 mg per cent respectively as reported by Bressani and Elias (1974) and Patwardhan (1962). Sood *et al*, (1982) carried out a study of mineral composition of nine mung varieties. In their studies, calcium and iron were reported to range from 88.00 to 198.00 mg and 3.70 to 8.80 mg respectively by dry weight basis.

Haytowitz and Mathews (1986) had studied the mineral composition of eight pulse grains viz. mung bean, blackgram, cowpea, drybean, chickpea, pigeon pea, lentil and soyabean. In these pulses, calcium was in the range of 51.00 mg to 277.00 mg per 100g, iron 5.23 to 15.70 mg, magnesium 115.00 to 250.00 mg, phosphorus 166.00 to 704.00 mg, zinc 2.68 to 4.89 mg, copper 0.66 to 1.66 mg and manganese 1.02 to 2.52 mg. Improved cowpea varieties are reported to have higher levels of minerals 8.30 to 15.30 mg iron per 100 g and 13.50 to 20.80 mg calcium per 100 g than local varieties as reported by Haytowitz and Mathews (1986)

Chickpea is a good source of iron and its availability is highest as compared to other food legumes (Cown *et al.*, 1987). Though pulses are a good source of minerals, the major portion of phosphorus is reported to exist in its phytate form (Ohage *et al.*, 1984). The irrigation treatment to chickpea cultivars significantly enhanced the calcium, phosphorus and iron contents over those grown under rainfed conditions (Chavan *et al.*, 1994).

Cowpea seeds contains vitamins like thiaime (0.74 mg per cent), riboflavin (0.42 mg per cent) and niacin (2.81 mg per cent) as reported by Bressani (1985).

Sharma *et al.* (1991) evaluated the nutritional quality of some improved varieties of mung bean and reported to contain 8.20 to 8.80 per cent moisture.

From the nutrition point of view, the protein content and its digestibility, the levels of limiting amino acids and the anti nutritional factors are also important (Rosaiah *et al.*, 1993).

The importance of protein to over all diet and health has been recognized for many years, however the quality of protein sources has been a subject of great debate. Pulse protein vary greatly in their content of amino acid, (Henley and Kuster, 1994).

Evans *et al.* (1978) noted that generally a high protein content was not indicative of a high sulphur amino acid content. Considerable differences were observed in the concentration of the major protein fraction of pigeonpea genotypes, globulin and glutelin. The globulin was noticeably higher in high protein genotypes than in normal protein genotypes and the reverse was true for the glutelin fraction. The storage protein globulin is also observed to constitute the major proportion of the legume seed protein (Umaid Singh *et al.*, 1990).

The higher levels of sulpher amino acids inthe glutelin than in the globulin fraction of pigeonpea have led to the suggestion that cultivars with a higher ratio of glutelin to globulin should be identified to improve their seed protein quality (Singh and Jambunathan, 1982).

From the nutrition point of view, the levels of both methionine and cystine should be considered together, since lysine and sulphur containing amino acids are the protein components which complement each other in cereal legume based diet (Rosaiah *et al.*, 1993).

The contents of sulphur amino acids were of particular interest because these amino acids are limiting in legume seeds (Evans and Bandemer 1967 and Evans *et al.*, 1978). A study conducted in samples of seven different legumes (soy, chickpea, limabean, cowpea, pea, navybean and blackbean) revealed that all had methionine as limiting amino acid (Kan and Shipe, 1984). Methionine and cystine are reported to be the primary limiting amino acids in all the pulses as reported by Ahmad *et al.* (1975), Pal *et al.* (1975) and Hamidullah *et al.* (1988).

Assessment of amino acid composition of mungbean, lathyrus, chickpea, lentil, fababean, vetch dry bean and pea by Bhatty (1982) revealed that all were deficient in methionine and cystine and rich in lysine and threonine.

Amino acid analysis of cowpea indicated methionine and cystine as the limiting amino acids as reported by Idourane *et al.* (1989), Ologhobo and Fetuga (1982), Kochhar *et al.* (1988) and Gabriel and Giovanni (1991). According to Rao *et al* (1979) greengram contains amino acids such as tryptophan (1.1 g/16gN), methionine (1.00 g/16g N) and lysine (5.40g/16g N). Cowpea varieties are reported to contain 8.25 to 10.66 per cent arginine, 5.25 to 6.11 per cent lysine and 1.25 to 2.77 per cent tryptophan by (Habib, 1989).

Gabriel and Giovanni has reported a range of values for cystine (0.91 to 1.17g/16gN) and methionine (12.4 to 14.2g/16gN) in cowpea varieties. Cystine in cowpea was observed to be in the range of 0.03 to 0.50g/16gN as reported by Kochhar *et al.* (1988). Similar findings were observed by Evans and Boulter (1974) and Ologhobo and Fetuga (1982).

Irrigation significantly enhanced the methionine and tryptophan content over those grown under rainfed conditions indicating that even crop management significantly alter the quantity of specific amino acids. (Chavan *et al.*, 1994).

One of the major draw back is that sulphur amino acid content in legumes is correlated negatively with protein content (Blis and Hall, 1977 and Bressani and Elias, 1988), because sulphur amino acid content generally declines as protein concentration is increased and a higher percentage of protein in the food legume would therefore represent poorer protein quality especially with respect to sulphur amino acids. A low and negative correlation between seed yield and protein is also reported by Deshpande (1992).

The low level of the sulphur amino acids should not have serious nutritional implications since legumes are usually consumed in combination with cereal based foods which are relatively high in methionine. Such blends would bring the essential amino acid composition closer to the FAO recommended level (Gabriel and Giovanni, 1991).

Biological evaluation of pigeonpea genotypes by Umaid Singh *et al.* (1993) indicated significant differences in biological values among the genotypes. Biological parameters of pigeonpea genotypes such as true digestibility, biological value, net protein utilization and utilisable protein are reported to be in the range of 87.60 to 92.80 per cent, 61.00 to 70.60 per cent, 56.60 to 65.40 per cent and 12.10 to 14.80 per cent.

According to Chitra *et al.* (1995) the mean values of protein digestibility of mungbean and urdbean dhal were 70.00 per cent and 59.90 per cent respectively.

Varietal difference seemed to have no effect on feed efficiency ratio and protein efficiency ratio values, as reported by Kamlesh and Neelam (1993). It was also reported that varietal difference in vegetable peas had no effect on the apparent digestibility, true digestibility, biological value, net protein utilization and utilisable protein.

Protein digestibility in legumes is known to be lower than that of either animal derived or most cereal derived proteins. Although the values reported in the literature are variable, they can be lower than 50.00 per cent for some species especially for raw seed as reported by Bressani and Elias (1980).

A number of compounds have been characterized as interfering with the release of amino acids during digestion or their subsequent absorption (Liener 1975, 1980). According to Phillips (1993), lectins and protease inhibitors are the most important modifiers of legume protein quality. Removal of trypsin inhibitor is seen to enhance the digestibility of soyabean protein some what, but can account for only about 40.00 per cent of the increase produced by heating the soy material. Phytate and tannins are heat stable factors and are observed to be also implicated in the reduction of protein digestibility (Salunkhe., 1982). Tannin is known to bind the protein and interfere with digestion as reported by Romero and Ryan (1978) and Sathe and Salunkhe (1984). Overall protein quality in actual diet depends on intake levels and requirements of the consuming organism as well as content and availability of amino acids (Phillips, 1993). Biological value is quite variable among and within legume species (Bressani, 1975).

According to Geervani and Theophilus (1980) processing improved the protein quality of the legumes significantly. Moist heat methods of processing improved the protein quality to a greater extent than dry heat methods. Fermentation and germination had no advantage over moist heat methods in improving biological quality of protein. Available lysine of roasted legumes was less than either boiled or pressure cooked legumes. However available methionine and cystine of roasted legumes was not lower than the boiled and pressure cooked legumes. No correlation was observed between PER and per cent nitrogen absorbed or retained, but the correlation between PER and total nitrogen retained was highly significant. Effect of storage conditions and processing treatments on the nutritional quality of cowpea protein and starch was determined by *in vitro* and *in vivo* (faecal and ileal digestibility) methods by Tuan and Phillips (1992). *In vitro* and ileal methods indicated that protein digestibility of the control group was significantly higher than that of test (Hard to cook) group (78.50 vs 75.30 per cent and 76.90 vs 66.60 per cent respectively) followed by cowpea cooked for 45 minutes (80.30 and 81.80 per cent respectively) and lowest in cowpea ground into flour (72.60 and 65.40 percent respectively.

Grinding before processing exacerbated differences between control and test groups. Reddy and Pushpamma (1986) studied the effect of storage of two local and three improved varieties of pigeonpea, greengram and chickpea for 12 months on protein quality and contents of lysine, methionine and tryptophan. Results show that decrease in protein quality and contents of the three amino acids were low in chickpea (10 to 15 per cent loss of amino acid) and pigeonpea (10 to 20 per cent) and high in greengram (20 to 30 per cent). Insect infestation caused a further decrease in these parameters. Generally losses were less in local variety than in improved varieties.

Monica *et al.* (1992) reported a slight increase in the digestibility with increase in cooking time of beans. The results suggest that cooking might have an adverse effect on heat labile antinutritional factors such as trypsin inhibitor and haemagglutinins as observed in bean seeds (Fernando and Bean, 1987). This suggests that longer the cooking time greater

is the destruction of these antinutritional factors and hence greater the improvement in protein digestibility (Monica *et al.*, 1992).

2.3 Antinutritional factors in pulses

Legumes contain a variety of undesirable chemical substances termed antinutrients that are known to exert a deleterious effect when ingested by man or animals. These substances include phytic acid, trypsin inhibitors, flatus producing oligosaccharides and tannins which can cause adverse physiological responses or diminish the availability of certain nutrients to animals or humans.

Nutritional role of pulses are limited by several factors including low protein digestibility, antinutritional factors and flatulence and poor cooking quality (Khan and Ghafoor, 1978). Legumes contain some antinutritional factors which hinder the efficient utilisation, absorption or digestion of nutrients and thus reduce their bioavailability and their nutritional qualities (Liener, 1976).

Change and Satterlee (1982); Kochler *et al.* (1986) and Dhurandhan and Chang (1990) reported that legumes contain antinutritional factors such as trypsin and chymotrypsin inhibitors, haemagglutinins, saponins, phytic acid and others which can affect the nutritional value of proteins.

Legumes are cheaper protein sources and are used as a substitute or supplement to the relatively expensive animal proteins in the diet. However, they are underutilized because of the content of enzyme inhibitors, protein of low quality due to their deficiency in sulphur containing amino acids and flatulence factors (Sathe and Salunkhe, 1981). Nowacki (1980) has also reported that usefulness of legumes is decrease by the presence of toxic / antinutritional compounds associated with the large protein content in their seeds. Cowpea like other legumes synthesis and accumulate a variety of antinutrients which include phytic acid, trypsin inhibitor, flatus producing oligosaccharides and tannins and these compounds can cause adverse physiological responses or diminish the availability of certain nutrients to the consumer. The content of these substances have also been shown to vary with cultivar

(Gate house *et al.*, 1979; Ologhobo and Fetuga, 1983; Kochhar *et al.*, 1988 and Ogun *et al.*, 1989). Phytic acid is one of the typical antinutrients in legumes and is of significant nutritional interest.

According to Deshpande *et al.* (1982) most of the phytate is present in the outer aleurone layer of the cotyledons or the endosperm. Beal and Mehta (1985) reported that among different pulses, largest portion of phytate (91.10 per cent) was present in the gratified pea cotyledon. Nawab *et al.* (1988) has reported that the phytic acid content of brown bengalgram is more than that of white variety.

The phytate content of legumes are reported to vary from 0.40 to 2.00 per cent depending on the species (Deshpande *et al.*, 1982). Phytic acid content varied significantly from 7.48 to 8.10 g per kg^{-1} in chickpea varieties and a narrow variation of 6.47 to 6.68 g per kg^{-1} was observed in blackgram varieties (Arti *et al.*, 1989). Similar varietal difference in phytic acid content of cowpea, limabean and soyabean (Ologhobo and Fetuga, 1984) and mothbean (Khokhar and Chauhan, 1986) have been reported earlier. Phytic acid content of cowpea varieties ranged from 5.10 g kg^{-1} to 10.27 g per kg^{-1} (Gabriel and Giovanni 1991) which were in agreement with those of Ferguson *et al.* (1988) and Harland *et al.* (1988) but higher than those of Oke (1965) and Ologhobo and Fetuga (1983). This difference is attributed to the greater sensitivity of the anion exchange column separation method used, compared with the iron precipitation method of earlier workers.

Study conducted by Chitra *et al.* (1995) revealed that phytic acid content of pigeonpea genotypes arranged between 6.80 mg/g to 17.50 mg/g. This indicated a wide and significant variation in phytic acid content of pigeonpea genotypes.

Among various antinutritional factors, phytic acid may account partly for the low digestibility of protein (Liener, 1976). Knuckles *et al.* (1985) reported that phytic acid inhibit the proteolytic enzymes. It forms complexes with protein as reported by O'Dell and Boland (1976) and Cheryan (1980). Complexing between phytate and protein has been reported for several proteins of cereals and legumes and this might affect the protein digestibility and bioavailability (Reddy *et al.* 1982).

Phytate is also reported to inhibit proteases (Singh and Krikorian 1982); Deshpande and Cheryan 1984; and Serraino *et al.*, 1985) and amylases (Yoon *et al.*, 1983; Deshpande and Cheryan, 1984).

Phytic acid lowers the bioavailability of minerals (Davies and Nightingale, 1975; Nolan and Duffin, 1987). Phytic acid reduces the bioavailability of multivalent minerals (Fardiz and Markakis, 1981). Phytates are also known to form complexes with dietary essential minerals in legumes thus rendering them poorly available to man and monogastric animals are reported by Reddy *et al.* (1982). It Chelates essential dietary minerals such as zinc, calcium, magnesium and iron thus decreasing their utilization (Kratzer, 1965). Davies and Nightingale (1975), Nolan and Duffin (1987) and Ali and Harland (1991) have reported that phytic acid lowers the bioavailability of minerals. Although legumes contain relatively large amounts of iron, availability is low because of factors such as phytate, tannin and fibre components though to interfere with non haem iron, utilisation (Gillooly *et al.*, 1984; Hazell, 1985; Rossander, 1987). Among the factors potentially involved in determining the low availability of iron from vegetable foods, there is concern about the true role of phytate, Published data for the effectiveness of phytate as an inhibitor of iron availability are conflicting. The studies of Hallberg *et al.* (1987) indicate that bran inhibits dietary iron absorption but the hypothesis about the influence of phytate on this effect is controversial. Simpson *et al.* (1981) showed that iron absorption was inhibited by dephytinised bran as much as by whole bran and attributed the effect of an unidentified factor. On the other hand Hallberd *et al.* (1987) identified phytate as the main determinant of the inhibitory effect of bran. Findings of Ginevra *et al.* (1991) indicates that, although phytate consistently modifies iron dialysability, it is difficult to identify a quantitative relationship between phytate content and non dialysability.

A highly significant and negative correlation was observed between the protein digestibility and the concentration of phytic acid in pigeonpea and chickpea as reported by Singh *et al.* (1991) and Chitra *et al.* (1995). Yadav and Khetarpal (1994) also reported similar correlation.

The term polyphenols refers to a complex family of phenolic compounds and those that precipitate proteins from aqueous solutions are called tannins (Earp *et al.*, 1981) and majority of these compounds are concentrated in the seed coat (Singh, 1984 and Bressani *et al.*, 1988). Elias *et al.* (1979) and Singh and Jambunathan (1981) have reported that tannin in plant foods are concentrated mainly in the seed coat, where they are positively correlated with the colour of the seed coat.

As reported by Phirke *et al.* (1982) blackgram seeds contain the highest concentrations of polyphenol followed by purple, reddish purple, brown and the white varieties of bengalgram. According to Reddy *et al.* 91985) tannin content of dry bean is 0 to 2.00 per cent depending on bean species and colour of seed coat. Phirke *et al.* (1982) also observed that the brown and cream coloured beans contained significantly higher amounts of polyphenols than white coloured for different cultivars of dry beans. A similar observation was made by Ekpenyoung (1985) for cowpea and by Sunday and Uzodima (1993) for beans, Ningsanond and Oovaikal (1989) have reported that tannin content in red cowpea flours ranged from 3.00 to 4.50 mg per g sample. Shindi *et al.* (1991) have also reported that polyphenol content was maximum in white coloured varieties of bengalgram. Total polyphenol contents of the brown or cream coloured cowpea were similar (1.15 to 1.96 mg) but higher amount (1.30 mg) was found in white beans as reported by Sunday and Uzodima (1993).

Udayasekhara Rao and Deosthale (1982) studied the tannin content of different varieties of pulses and observed significant varietal difference. Tannin content of mung varieties were found to very from 216.00 to 273.00 mg per 100 g (Sharma *et al.*, 1991). Change *et al.* (1994) analysed tannins of 3 cultivars of cowpea at 3 maturity stages. Cultivars differed in testa darkening which increased during maturation and darker testa was found to have greater tannin concentrations. It was also reported that 96 per cent of the tannins inthe cowpea was observed to be present in testa. Singh (1984) and Bressani *et al.* (1988) reported that the low digestibility of pulses may be due to higher polyphenol content. It

was also reported that polyphenols decrease protein digestibility in animals including humans, probably by making proteins partially unavailable or by inhibiting digestive enzymes and increasing faecal nitrogen. The formation of tannin complexes with dietary protein and digestive enzymes may contribute to the low digestibility of cooked beans (Bressani and Elias, 1980; Singh and Eggum, 1984; Reddy *et al.*, 1985).

Deshpande (1992) has reported on the negative nutritional effect of the tannins. The major effect is to cause growth depression by decreasing the digestibility of protein and carbohydrate This is most likely due to the interaction of tannins with either protein or starch to form enzyme resistant substrates.

Interaction with enzyme themselves is also reported to cause an interference with the digestibility of these substances. Elias *et al.* (1979), Sathe and Salunkhe (1984); and Hernandez *et al.* (1991) also reported that polyphenol lowers the digestibility of proteins and starch as reported by Thompson and Yoon (1984). Other antinutritional effects that have been attributed to the tannins include damage to the intestinal mucosa (Mitjavila *et al.*, 1977) and the inherent toxicity that is found to be caused by tannin metabolites absorbed from intestine (Hageman and Butler 1991).

According to Bressani *et al.* (1982) binding of tannins to lysine of bean proteins may decrease the lysine availability. Tannins are also observed to interfere with the absorption of glucose (Welch *et al.*, 1989) and iron (Garcia *et al.*, 1990).

Pulses are known to produce flatulence, which causes considerable inconvenience when consumed in large quantities. Certain oligosaccharides like sucrose, stachyose and raffinose have been identified to be associated with the gas producing factor. Raffinose, stachyose and verbascose are the major oligosaccharides of the raffinose family of sugars (Iyenger and Kulkarni, 1977). Raffinose and stachyose are the most gas forming sugars as reported by Rao and Vamil (1983) and the latter inducing maximum flatus (Cristofaro *et al.*, 1974).

Rachis *et al.* (1970) reported that consumption of large amounts of pulses cause

flatulence with attendant rectal ejection of gases occasionally accompanied by nausea, cramps and diarrhoea, besides social discomfort.

Apparent potency of legume beans in producing flatulence has been attributed entirely to stachyose and raffinose (Wagner *et al.*, 1976). Flatus causing potency of pulses is positively correlated with oligosaccharide content (Reddy *et al.*, 1980). These oligosaccharides viz raffinose, stachyose and verbascose remain undigested and consequently unabsorbed through the small intestine and metabolized by the intestinal flora as reported by Cristofaro *et al.*, (1974).

Cowpea like other legumes are reported to contain raffinose family oligosaccharides and hence have the tendency to induce flatulence (Sugimote and Van Buren, 1970). Savitri and Desikachar (1985) studied the oligosaccharide (raffinose, stachyose, verbascose) content of different legumes and they had found that greengram contained the lowest content of oligosaccharides.

Wide interstrain variations were observed in concentration of oligosaccharides ie raffinose (0.66 to 1.47 per cent) and stachyose (0.41 to 1.22 per cent) on dry weight basis as reported by Batra and Dhindsa (1989). In addition to genetic factors, environmental conditions influence the variability in the mono and oligosaccharide contents of dry beans (Cerning *et al.*, 1975 and Agbo, 1992).

Oligosaccharides occur in significant levels (3.00 to 15.00 per cent) in most dry pulses (Salunkhe *et al.*, 1985) and have been correlated to the occurrence of flatulence in monogastric animals, including man. However, there is evidence that factors other than oligosaccharides contribute to flatulence (Wagner *et al.*, 1976). Whatever the aetiology of this effect, it is a major constraint of legume consumption.

Substances possessing the property to agglutinate red blood cells are known as phyto ha0emagglutinins (lectins). These substances, protein in nature, are distributed among pulses (Liener, 1982 and Gupta, 1987). Beside, their ability to agglutinate red blood cells, Liener (1982) has reported that they exhibit other chemical and biological properties which

include interaction with specific blood groups, agglutination of tumor cells and toxicity towards animals. Saponins containing foods when consumed in large quantity cause abdominal pain, vomiting and diarrhoea.

2.4 Cholesterol lowering effects of legume

Legume protein has been implicated in health related issues other than purely nutritional effects. An interesting observation has been the effect of legume protein and even blends of amino acids stimulating legume protein on serum cholesterol levels.

Elevated plasma cholesterol level is a major risk factor of coronary heart disease (David, 1987).

In an age when nutritionists are emphasizing the need to decrease fat intake, particularly saturated fat and sugar in the diet and eat more complex carbohydrates including dietary fibre (Coma, 1984, and NACNE, 1983) legumes are an ideal staple diet. Human studies have shown that the consumption of legumes as a major part of the diet can result in marked reduction in the level of cholesterol circulation in the plasma (Mathur *et al.*, 1968 and Jenkins *et al.*, 1983).

According to Susan *et al.* (1987),the cholesterol lowering effect of legumes is due not to a single factor but to a number of factors working together. Hypocholesterolemic agents occurred in leguminous seeds are protein, non starch polysaccharides, polyunsaturated fatty acids, saponins, plant sterols and isoflavones. Several studies in animal and man have shown whole legumes to be effective cholesterol lowering agents when consumed on a habitual basis particularly when the background diet is high in fat and cholesterol.

It has been suggested and largely substantiated that eating a low fat diet will help to lower serum cholesterol levels (Snook *et al.*, 1985 and Weisweiler *et al.*, 1986). Legumes can make a significant contribution to the energy content of diet without contributing markedly to its fat content.

Saturated fat is an important determinant of a subjects response to dietary cholesterol

(Susan *et al.*, 1987). Connor *et al.* (1986) have proposed that the atherogenicity potential of food is predictable from cholesterol saturated fat index. Legumes which contain no cholesterol and therefore lower the cholesterol saturated fat index of a diet.

Legume oils although usually present in small quantities are highly unsaturated, containing in particular linoleic and linolenic acids. Experiments showed a highly significant depression of the cholesterol levels when rats were fed with extracted lipids from cowpea (Mahadevappa and Rama, 1983).

Studies have provided strong evidence of a positive correlation and link between the intake of animal protein and the incidence of coronary heart disease. Conversely, a negative correlation has been described between mortality from Coronary Heart Disease and the consumption of vegetable protein. There are a number of reports which indicate that the nature and quality of protein in the diet have a definite effect on the lipid levels in both man and experimental animals (Venugopal, 1976).

The effect of protein on lipid among other things depends on its amino acid composition as reported by Kritchevsky *et al.* (1982). According to Rajmohan (1989) many of the amino acids exert significant effect on lipid metabolism and therefore the effect of a protein may depend among other things on its amino acid content.

According to Muraleedhara Kurup (1984) the nature of amino acid in the diet has an effect on the level of liver lipid. Earlier experimental finding indicated that accumulation of lipid in rats fed egg albumin diet may be due to an excessive amount of sulphur amino acid and lack of lipid accumulation in liver in rats fed low casein diet may be probably due to the deficiency of sulphur amino acids. Lysine and methionine are found to have opposite effect on lipid metabolism in the liver. According to him, adequate level of lysine in the diet corrects the impaired lipid metabolism observed in lysine deficient to the normal level. On the other hand, the increased concentration of cholesterol and triglycerides in the serum and aorta observed in rats fed excess methionine is an important observation, since hypercholesterolemia and hypertriglyceridaemia as already stated are important that

legumes contain few mono and disaccharides and unless they are consumed as a processed product, they have been shown to decrease triglyceride levels in hypertriglyceridaemic subject.

The involvement of dietary fiber in lowering the blood cholesterol level has been reported by Singh *et al.* (1983). Fiber in legumes would be expected to act along with protein to affect serum cholesterol, both by limiting digestion rates of macronutrients and by binding steroid in the gut (Phillips, 1993).

Saponin consumption is also associated with increased faecal excretion of bile acids and neutral steroids as reported by Topping *et al.* (1980). Saponins are sterols found in pulses and which lower serum cholesterol level (Oakenfull, 1981). Saponin combines with cholesterol and bile acids in the intestine, to form large mixed miscelles, which are not available for absorption. The binding of bile acids provides a second mechanism for the Hypocholesterolemic effect since it represents an interruption of the enterohepatic cycle.

Isoflavones are phenolic compounds belonging to the flavanoid group and are synthesized during germination of pulses and were shown to lower serum cholesterol levels. The mechanism of action of isoflavanols is not known but the structure of these compounds are like that of oestrogenic hormones and they do possess some oestrogen like activity.

Earlier findings revealed that pulse proteins contain adequate quantity of lysine and are deficient in sulphur containing amino acid methionine.

While studying the effect of dietary pulse proteins in atherosclerosis studies conducted in Kerala University indicate that not all pulse proteins have cholesterol lowering action (Venugopal, 1976).

Lysine : Arginine ratio of protein may influence serum cholesterol level and atherogenicity. Effect of alteration of lysine : arginine ratio on cholesterol metabolism has been investigated in detail by Rajmohan (1989) and found that there is an optimum ratio of

one as far as hypocholestremic effect of protein is concerned. Increase in ratio produced higher serum and tissue cholesterol while decrease in ratio also produced higher serum and tissue cholesterol though significantly lower than the former case. It was reported that decreases in lysine : arginine ratio increase the activity of some lipogenic enzyme risk factors in atherosclerosis.

Anderson *et al.* (1984) reported increase in the activity of HMG COA reductase in liver indicate increased hepatic cholesterogenase, since the activity of this enzyme correlates very closely with the rate of cholesterogenesis in the tissues. Increased concentration of bile acids with decease in lysine : arginine ratio indicate increased hepatic degradation of cholesterol to bile acid. The decrease in the concentration of cholesterol in liver with decrease in lysine : arginine ratio may be due to the fact that the rate of cholesterol degradation may be more than the rate of its synthesis.

2.5 Effect of processing and cooking on the nutritional composition of pulses.

In India legume grains are processed and consumed in a variety of forms depending on cultural and taste preferences. Traditional methods of processing and cooking legumes have been evolved to give safe, appetizing and nutritious products. In developing countries such as India, where the consumption of legumes remain high, many varied and appetizing dishes are prepared by using different methods of processing including soaking, cooking, sprouting, fermentation, dehulling, roasting, cooking of sprouts, parching and soaking over night and cooking until soft.

In order to improve the nutritional quality of dry beans treatments such as soaking, cooking or germination have been applied (Vishalakshi *et al.*, 1980) and the effects are reported to vary with cultivar and the treatments (Zacharia and Ronald, 1994).

Processing has a minimal effect on the total nitrogen and protein content of dry beans and peas (Elias *et al.*, 1979 and Terri *et al.*, 1990). Srivastava *et al.* (1988) reported that soaking in solution of sodium bicarbonate caused leaching of protein and hence decrease

the protein content in seeds. The protein content of the canned beans and brines was similar to the nitrogen content of cooked beans and brines as reported by Elias *et al.* (1979).

According to Terri *et al.* (1990) unlike the total nitrogen content, significant decrease in the non protein nitrogen content of dry beans occur during processing. Free amino acids being highly water soluble are observed to leach into the soak water and canning brine (Terri *et al.*, 1990).

Meiners *et al.* (1976) reported that the cooking of cowpea reduced crude protein levels. Nitrogenous, compounds including free amino acids and short chain polypeptide are reported to leach from the tissues during soaking and canning (Terri *et al.* 1990). It was also reported that these losses are accompanied by greater losses of non-nitrogenous compounds, thus contributing to the observed non significant change in the total nitrogen content of the raw and processed beans. According to Elias *et al.* (1979) losses in the protein content and composition of dry beans during processing have been attributed to the solubilisation of proteins, hydrolysis of protein to free amino acids and degradation via millard reaction.

In general processing improved the protein quality of legumes significantly (Usha *et al.*, 1981). It was also reported that moist heat methods of processing improved the protein quality to a greater extent than by dry heat methods. The increased nutritional value may be the result of an increased accessibility of bean proteins to enzymatic attack (Romero and Ryan, 1978). According to Burns (1987), it has been well established that the nutritive value of phaseolous bean protein is enhanced by thermal processing especially by moist heat treatments. This may be due to denaturation of proteinaceous antinutritional factors because these factors require their structural integrity inorder to exert their negative *invivo* effects.

Tuan and Phillips (1992) reported that boiling cowpea seeds improved both overall and protein quality when compared to raw seeds.

Germination was found to have no advantage over moist heat methods in improving biological quality of protein as reported by Geervani and Theophilus (1980). However

germination is reported to cause an increase in the protein content of legumes as reported by Fordham *et al.* (1975), Hsu *et al.* (1980) and Abdul Khaleque *et al.* (1985).

According to Nnanna and Phillips (1989) germination had little effect on amino acid profile of cowpea. *Invitro* protein digestibility was not improved significantly by germination nor by decortication but improved by cooking. The nutritional quality of protein was found to increase during germination in mungbean (Noor *et al.*, 1980) and germination had no effect on protein content in some pulses as reported by Chandrasekhar and Jayalakshmi (1978).

Processing of the pulses was reported to influence these mineral profile. Longe (1983) assessed the cooking quality of 13 varieties of cowpea and reported that cooking resulted in losses of 5.20 to 69.50 per cent for calcium and 13.90 to 33.30 per cent of magnesium. Hashim and Mohsan (1986) found that boiling reduced calcium and iron content significantly in *Vigna sinensis*.

An increase in ionisable iron was observed on sprouting which might be due to release of iron from protein bound combinations (Singh and Banerjee, 1953). Ionisable iron content is observed to increase due to soaking in water and increased continuously with increasing period of germination. While soluble zinc content was lowered by 25 per cent after over night water soaking but later germination results in a progressive increase. Removal of tannin could be a factor responsible for the observed increase in available iron and zinc. Deosthale (1982) has also reported that during soaking and germination several enzyme systems become active and bring about profound changes in the minerals of the pulses.

Rao and Deosthale (1983) had reported significant decrease in iron, copper and zinc contents during cooking. Borade *et al.* (1984) reported significant decrease in calcium content during cooking. Neerjarani and Charanjeet (1993) observed significant reduction in iron content of fababeans on pressure cooking.

Losses in protein and ash contents of dhals due to cooking were noted by Chavan *et al.* (1983) when the cooking fluids were discarded. Loss in ash and protein may

be partly due to leaching of soluble protein into the processing water as reported by Mbajuna (1995)

2.6 Effect of processing and cooking on the antinutritional factors in pulses.

Pulses are consumed after processing and cooking and heat treatment and soaking are reported to reduce the antinutritional factors in pulses.

Rao and Deosthale (1982) Barroga *et al,* (1985) and Jood *et al.* (1987) reported that different processing and cooking methods have been known to affect the level of several antinutrients including polyphenols.

Studies conducted by Arti *et al.* (1989) revealed that soaking the seeds for 12 hours reduced significantly the phytic acid contents of all the cultivars of both chickpea and blackgram. The phytic acid loss was 11.00 to 16.00 per cent in chickpea and 25.00 to 30.00 per cent in blackgram.

Bishnoi *et al.* (1993) studied the effect of domestic processing and cooking methods on phytic acid and polyphenol content of pea cultivars. Soaking as well as dehulling of soaked seeds contributed significantly towards lowering down the phytic acid content in field and vegetable pea cultivars. Longer periods of soaking, resulted in greater loss in phytate content. The reduction in phytic acid content of soaked and dehulled pea seeds of different varieties were observed to range from 7 to 9 per cent over the control values. The loss of phytic acid in the soaked pea seeds may be because of leaching of phytate ions in to soaking water. Similar results for reduction in phytic acid in the soaked legumes have been reported earlier by Deshpande and Cheryan (1983); Ologhobo and Fetuga (1984) and khokhar and Chauhan (1986).

The decrease in the level of phytic acid of legumes seeds during soaking may be attributed to leaching out of this antinutrient into the soaking water under the influence of concentration gradient. Such losses may be taken as a function of changed permeability of seed coat. Soaking an integral part of traditional methods of processing legume grains in

India, thus offers the dual advantage of reducing energy costs by shortening cooking time as well as rendering the grains nutritionally superior by removing phytic acid. According to Arti *et al.* (1989) cooking further lowered the phytic acid contents significantly in pulses.

Bishnoi *et al.* (1993) reported that cooking of unsoaked pea seeds lowered the phytic acid content but the loss appeared to be less than in the peas cooked after soaking or after soaking and dehulling. It was also found that there was significant reduction in phytic acid content due to pressure cooking of unsoaked seed. Pressure cooking of soaked seeds causes a greater loss in phytic acid content than that of unsoaked seeds. According to Kumar *et al* (1978) an obvious decrease was noticed in phytic acid content of field and vegetable pea varieties due to ordinary and pressure cooking. Similar reduction in phytate content during the combined process of soaking and cooking has been reported in legumes including moth beans and fababeans (Khokhar, 1984 and Sharma, 1989).

The phytic acid content of different varieties of beans under different processing conditions was estimated by Lalitha *et al.* (1987) and found that both soaking and cooking reduced 26 to 37 per cent of the phytic acid content in all the varieties. According to Beal and Mehta (1985) cooking peas resulted in 13 per cent phytate reduction.

Sprouting was also instrumental in lowering significantly the phytic acid level of legume grains. Phytic acid loss was 28.00 to 34.00 per cent in chickpea and 39.00 to 45.00 per cent in blackgram cultivars. The reduction in phytic acid was enhanced when the sprouts were cooked and was significant in both legumes. The cooked sprouts of legumes appeared to have the minimum phytic acid, the losses representing the cumulative effects of soaking, germination and cooking. The major loss appeared to be caused by germination, but cooking further reduced the total phytic acid when it followed sprouting (Arti *et al.*, 1989).

According to Kaur and Kapoor (1990) antinutritional factors like polyphenols, phytic acid and saponin content in greengram decrease with increase in soaking and sprouting time. It was also reported that the decrease in antinutritional factors was much greater in soaked seeds than in unsoaked seeds.

According to Ologhobo and Fetuga (1984) germination and soaking were most effective in reducing phytate content. Cooking and autoclaving are reported to alter slightly phytates and phytate content in all the varieties. It was also reported that phytic acid content of different varieties of cowpea were greatly reduced by germination.

Phytate activity during germination as reported in some legume grains (Mandal *et al.*, 1972 and Michael Eskin and Wiebe, 1983) may account for the low level of phytic acid in sprouts. Sprouting, autoclaving and soaking appeared to be the most effective methods of processing in lowering phytic acid content of chickpea and blackgram. Cooking also attributed to the loss of phytic acid but to a lesser extent. Cooking of soaked seeds lowered phytic acid by 20.00 to 26.00 per cent in chickpea and 35.00 to 40.00 per cent in blackgram where the loss was 7.00 to 11.00 per cent and 6.00 to 9.00 per cent respectively in these pulses when unsoaked seeds were cooked (Arti *et al.*, 1989).

Phytic acid content in *Phaseolus vulgaris* were reduced by 57.80 per cent after 5 days germination (Sathe *et al.*, 1983) and germination for 10 days needed, to cause 75 per cent decrease of phytate in peas (Beal and Mehta, 1985). According to Bishnoi *et al.* (1994) a loss of 6.00 to 8.00 per cent phytic acid occurred during 12 hours germination of peas which was enhanced further with the increase in the period of germination. Loss of phytate acid during germination was observed in various plant foods (Lolas and Markakis, 1975 and Mandal *et al.*, 1972).

Germination has been reported earlier by different workers to have a diminishing effect on the phytic acid content of various legumes including cowpea, soyabean and Lima bean (Ologhobo and Fetuga, 1984).

According to Reddy *et al.* (1985) the antinutritional activity of bean tannins can be reduced by processing like dehulling, soaking, cooking and germination. Tannic acid content of different cowpea varieties were partly affected by autoclaving and cooking reduced tannic acid contents by 31.00 to 47.31 per cent (Ologhobo and Fetuga, 1984) and 70 per cent decrease in tannin content was brought about after cooking raw pulses (Udayasekhara Rao and Deosthale, 1982).

Ordinary cooking of seeds has marginal reducing effect on polyphenolic content of different cultivars. A loss of 8 to 9 per cent was observed in peas which were cooked without prior soaking. Cooking after soaking brought about a significant decrease (49 to 56 per cent) in polyphenolic content of all the pea varieties (Bishnoi *et al.*, 1994).

Cooking has been reported to be effective in significantly reducing tannin content of common bean (Elias *et al.*, 1979), lima bean (Ologhobo, 1980), soyabean (Bressani *et al.*, 1982) and winged bean (Tan *et al.*, 1984).

According to Udayasekhara Rao and Deosthale (1982), as a result of overnight soaking in water, 25 per cent of tannin was lost in greengram and when germination was continued for 48 hrs, a further 25 per cent loss of tannin was observed. Rao and Prabhavathi (1982) attributed the loss of tannin in beans during germination, to the presence of polyphenol oxidase and to enzyme hydrolysis. Some loss of tannin during germination may also be expected by this leaching in the water. Soaking of cowpea for 3 days decreased tannic acid by 13.50 per cent (Ologhobo and Fetuga, 1984). Nehad and Moneam (1990) reported 64.76 to 78.88 per cent loss in tannin by soaking prior to cooking. Kaur and Kanpoor (1990) reported a decrease in tannin in rice beans during soaking and cooking.

On pressure cooking of unsoaked seeds of different pea cultivars a significant reduction (11 to 12 per cent) in polyphenol level was observed. This loss was more when pressure cooking of the soaked seeds were done (Bishnoi *et al.*, 1993).

Study conducted by Bishnoi *et al.* (1993) revealed that germination (48 hrs) is the best method followed by pressure cooking and ordinary cooking of soaked dehulled seeds, dehulling and soaking for lowering the levels of phytic acid and polyphenol in field and vegetable peas. These are the simple and inexpensive processing methods which can be followed to increase the nutritive value of legumes.

Neerajarani and Charanjeet (1993) reported that pressure cooking resulted in a maximum loss (66 per cent) of phenols followed by sprouting (38 per cent) of fababean. According to them, a drastic reduction on pressure cooking might be due to destruction of

phenols at high temperature and some leaching of the components in cooking water. Reduction in tannin was 30 per cent in pressure cooking and 15 per cent in sprouting.

Chang *et al.* (1994) reported that heating in water reduced tannin in whole cowpea (38 to 76 per cent). Most tannin occurred in the testa and hence dehulling was found to eliminate upto 96 per cent of the tannins. Heating of the seed in water for 30 minutes was found to remove 38 to 76 per cent of tannins depending on the cultivar and maturity.

Zacharie and Ronald (1994) studied the effect of processing on the tannin content of beans. A decrease in tannin content was observed after soaking (28.75 per cent), cooking (59.81 per cent) and soaking and cooking (84.64 per cent). This reduction was probably due to diffusion of this antinutrient in water or to the formation of insoluble tannin protein complexes not extractable from beans.

Loss of tannin may be due to its solubility in water as tannins are known to be water soluble (Mbajuna 1995). Attia *et al.* (1994) studied the effect of cooking and decortication on antinutritional factors. Decortication was observed to cause considerable losses in dietary fiber components and polyphenols. According to Neerajarani and Hira (1994) pressure cooking resulted in a minimum loss of phenolic compounds (66.00 per cent) followed by sprouting (38.00 per cent), dehulling (29.00 per cent) and roasting (27.00 per cent). All these treatments resulted in a significant loss of tannins.

Trypsin inhibitors are substances which have the ability to inhibit the proteolytic activity of certain enzymes. Trypsin inhibitor present in the kernel are heat labile (Liener, 1980) and their potential hazard can be overcome by moist heat treatment as reported by Janardhanan and Nalini (1991). Heat inactivation of protease inhibitors in legumes have been reported by Ravindran and Ravindran (1988), Ogun *et al.* (1989) and Rao *et al.* (1989). The rapid initial inactivation of trypsin inhibitor activity may be explained by proposing a catalytic effect of water on the inhibitor protein molecule while attributing heat denaturation of the protein during the second phase primarily to a thermal effect (Rao *et al.*, 1989).

According to Chang *et al.* (1981) over 92 per cent trypsin inhibitor activity destroyed with in 12 minutes of conventional heating (boiling in water) of *Vigna unguiculata*. Heating of soaked seeds at 121 C for 30 minutes completely destroyed trypsin inhibitor activity in all *Vicia faba, Vigna unguculate, Vigna radiata and Lens culinaris* (Salunkhe, 1982).

Salunkhe (1982) reported that soaking followed by germination considerably reduced the activity of trypsin inhibitor in pigeonpea.

Trypsin and chymotrypsin inhibitory activities declined gradually in shoot and endosperm and on the fifth day of germination there was almost a complete loss in trypsin inhibitor activity in pigeonpea (Veerappa and Paramjyothi, 1992) and greengram (Haider, 1981). The decrease in trypsin inhibitor activity during germination observed in mung seeds may be due to leaching on proteolysis as suggested by Wilson (1980).

Khokar and Chauhan (1986) reported that ordinary cooking, pressure cooking after soaking in plain water or salt solution and ordinary cooking of sprouts almost eliminated trypsin inhibitor activity from moth bean.

A significant decrease (83 per cent) in anti-tryptic activity was noticed upon soaking the pulse overnight (blackgram) and a complete loss of antitryptic activity was noticed on boiling as reported by Kaul and Bajwa (1987).

Ologhobo and Fetuga (1983) assessed the effect of processing on trypsin inhibitor activity in lima beans and it was reported that trypsin inhibitor was completely eliminated by cooking and soaking for 6 days with 34.64 per cent loss and germination was effective after 4th day. Ologhobo and Fetuga (1984) studied the effect of processing on the antinutritional factors in different varieties of cowpea. Trypsin inhibitor was completely eliminated by cooking and autoclaving. Soaking for 3 days decreased trypsin inhibitor activity by a mean of 31.20 per cent.

Gaspen and Jimmesh *et al.* (1992) reported that heating decreased the original trypsin inhibitor activity by 81.70 per cent after 5 minutes and 85.91 per cent after 10 minutes.

Zacharie and Ronald (1994) found that when compared with raw bean 97 to 98 percent decrease was observed for soaked and cooked beans and the reduction was due to thermal inactivation of trypsin inhibitor.

Legumes contain the raffinose family oligosaccharides and have the tendency to induce flatulence. Several investigators studied the effect of processing and cooking in reducing the flatus activity in legumes. Soaking affected the level of oligosaccharides in cowpea samples to various extent as reported by Richard and Esther (1993).

Decrease in oligosaccharides after soaking was reported by Silva and Braga (1982), Sosulski *et al.* (1982) and Jood *et al.* (1985). A mean reduction of 26.20 per cent of stachyose and 28.00 per cent for raffinose were obtained after 16 hours soaking. In an earlier study, Ogun *et al.* (1989) reported a 12.90 per cent reduction in the mean stachyose content of four cowpea cultivars soaked for 12 hours. The mechanism by which the oligosaccharides are eliminated is not clear. Although leaching has been suggested by Prince *et al.* (1988) the results of the work done by Richard and Esther (1993) and Silva and Braga (1982) suggests that leaching cannot be the only factor influencing the loss of oligosaccharides during processing. Inmarked contrast, Batra and Dhindsa (1989) observed that soaking of lentils in distilled water for 24 hours increased average concentration of individual as well as total oligosaccharides.

Cooking brought about a greater reduction in the level of oligosaccharides compared with soaking. Eventhough the level of reduction was not proportional to the duration of cooking the longest cooking time resulted in the greatest reduction in the level of oligosaccharides in cowpea samples. The reduction in the stachyose and raffinose levels averaged 28.60 per cent and 44.00 per cent respectively, after 50 minutes cooking (Richard and Esther 1993). Onigbinde and Akingele (1983) reported a mean decrease of 46 per cent and 50 per cent in the stachyose and raffinose content of 20 cowpea varieties after 45 minutes cooking.

The total saccharide contents of the soaked and canned beans were approximately 75 per cent and 45 per cent of that of the raw beans, with sucrose and oligosaccharides

undergoing the greatest losses (Terri *et al.*, 1990). Similar decrease in saccharide content have been observed during processing of dry beans and other legumes in studies conducted earlier by Reddy and Salunkhe (1980), Silva and Braga (1982) and Jood *et al.* (1985, 1986).

Soaking and canning of dry beans are reported to contribute to a decrease in the mono and oligosaccharide contents through the leaching and degradation of the saccharides as reported by Silva and Braga (1982) and Jood *et al.* (1985). Terri *et al.* (1990) reported that the leaching of the saccharides from the tissues into the soaking and canning brines was a major factor contributing to the decrease in the saccharide contents. Terri *et al.* (1990) reported that thermal degradation of oligosaccharides to mono and disaccharides also influenced the distribution of saccharides in the processed beans.

Inmarked contrast, Rao and Belavady (1978) and Savitri and Desikachar (1985) reported a slightly increased flatus producing capacity after cooking legumes. The difference in the pattern of changes in oligosaccharides on cooking might be due to difference in cooking procedures and the physical condition of the samples as reported by Batra and Dhindsa (1989). Non enzymatic hydrolysis of verbascose to stachyose, raffinose and sucrose during cooking might also contribute to increase in concentration of latter sugar (Batra and Dhindsa 1989).

Prince *et al.* (1988) reported that cooking alone will not be sufficient to bring about any significant reduction in the flatulence inducing activity of cowpea.

Considering that treatments such as soaking and cooking can change the physicochemical properties of legumes (Prince *et al.*, 1988). Crude enzyme treatment would seem to have the greatest potential as the technique to control the flatulence inducing activity of cowpea, and probably other legume flours (Richard and Esther, 1993).

According to Nnanna (1988) germination markedly reduced the flatulence potential and stachyose had disappeared after 48 hours germination of cowpea. Esteves and Luh (1985) reported that germination removed most of the raffinose and stachyose in the beans.

According to Jood *et al.* (1985) germination beyond 48 hours resulted in complete disappearance of raffinose, stachyose and verbascose. Germination for 24 to 72 hours progressively decreased total oligosaccharides in all the legumes (Savitri and Desikachar, 1985).

Germination of soaked seeds upto 3 days caused substantial decrease in all the oligosaccharides (Batra and Dhindsa, 1989). Pawastien and King (1984) reported that during germination, raffinose, stachyose and verbascose contents decreased rapidly from 0.74, 3.56 and 0.52 per cent respectively to 0.11, 0.22 and 0 per cent respectively after 73 hours. 24 hours germination is recommended as a reasonably good treatment for legumes for redaction of flatus production (Jood *et al.*, 1985).

Silva and Braga (1982) reported that oligosaccharides might also be released from the bound form during inhibition of water and this process may surpass the leaching out of these sugars from the seeds by diffusion, depending upon solubility. The released sugars are observed to be hydrolysed by galactosidase (Reddy and Salunkhe, 1980) during germination. Sathe *et al.* (1983) also reported complete disappearance of oligosaccharides in different legumes at 2 to 6 days after germination. Raffinose decrease significantly in fermented chickpea and cowpea as reported by Zamora and Fields (1979). Ejiofor and Oti, (1987) reported that fermentation appeared to reduce oligosaccharides.

Plant breeding could be an alternative approach to the reduction of flatus activity but the facts that oligosaccharides are suggested to play a role in defense mechanism against diseases (Albersheim and Darvill, 1985 and Ryan and Farmer,1991) in seed viability and cold acclimatisation (Castillo *et al.*,

1990) suggest that their elimination from the plant itself adversely affect the growth and yield of cowpea.

Review of the earlier research finding revealed that processing and cooking are effective in reducing or complete removal of antinutritional factors in pulses and increased the nutritional quality and digestibility of pulses.

MATERIALS AND METHODS

MATERIALS AND METHODS

The study entitled **"Assessment of quality of selected varieties of greengram and grain cowpea"** was taken up for a critical assessment of quality parameters of pulses viz physical and cooking characteristics, nutritional and antinutritional factors and to develop a quality index through a multivariate approach.

Methods of the study included

3.1 Selection of pulses based on the pulse cultivation and consumption pattern.

3.2 Selection of pulses evolved or recommended by Kerala Agricultural University.

3.3 Assessment of the physical and cooking characteristics of pulses.

3.4 Estimation of nutrients an antinutritional constituents present in these pulses.

3.5 Estimation of nutrients and antinutrients and biological factors determining the quality of proteins through animal experiments.

3.6 Assessment of hypocholesterolemic effect of pulses.

3.7 Assessment of hypocholesterolemic effect of pulses.

3.8 Statistical analysis.

3.1 Selection of pulses based on the pulse cultivation and consumption pattern.

Cowpea and greengram were selected based on a survey conducted to assess the pulse cultivation and consumption pattern of farm families in three districts of Kerala where area covered under pulse cultivation was more (500).

3.2 Selection of pulses

Five varieties each of cowpea (*Vigna unguiculata*) and greengram (*Vigna radiata*) were selected as detailed below.

Research station from where procured.	Name of the varieties	
	Cowpea	**Greengram**
Regional Research Station Kayamkulam	Pournami	Mg 161
	V 118	M 3
	Kanakamany	Pusa 8793
	Co 2	
National Seed Corporation	C 152	Pusa Baisakhi
Local Farms	Kozhinjipayar	

3.3 Assessment of the physical and cooking characteristics of pulses.

Several high yielding varieties evolved in pulses did not remain in the market for longer duration since they did not satisfy the requirements of consumers. Consumers prefer the varieties with appreciable cooking qualities having shorter cooking time, higher volume expansion after cooking, higher water uptake and lesser solid dispersion.

Physical Characteristics

Grain dimension (Length : Breadth)

The length and breadth of the pulses were determined by placing randomly selected ten grains over a grooved cardboard having graduations. The grains were arranged in such a way as not to leave any gap between the grains. The length : breadth ratio was calculated from the mean values.

Hundred grain weight and volume

Randomly selected hundred pulses were weighed and the weight was expressed in grams. Seeds used for 100 seed weight were then immersed in a cylinder containing water and the amount of water displaced was recorded as volume of seeds.

Seed density

Seed density was calculated from the values obtained for weight and volume.

Equilibrated moisture content upon soaking at room temperature (EMC - S)

About 5 g of pulses were soaked in excess distilled water for 24 hours at room temperature. The soaked pulses were transferred to double folded filter paper and the excess surface moisture was absorbed. Then the soaked pulses were transferred to tared petri dish and the weight was determined. After drying the samples in air oven at 105□C to constant weight, the loss in moisture was determined and the EMC S was calculated using the formulae

$$\text{EMC S per cent} = \frac{\text{Moisture content in gm}}{\text{Weight of soaked kernel gm}} \times 100$$

Cooking Characteristics

Optimum cooking time

50 ml of distilled water was taken in uniform sized test tubes and kept in a boiling water bath. When the water attained boiling point, 5 g of pulses were dropped. Grains were tested for doneness at intervals by pressing a grain each time between two glass plates to determine the optimum cooking time.

Elongation Ratio and Elongation Index.

Ten pulses were selected and measured their length and breadth and cooked as detailed above. Then the test tubes were taken out of the bath and suddenly cooled in water. Then the excess water was drained and the cooked grains were transferred to a folded filter paper. The length and breadth of the cooked pulses were determined using the groove board. Elongation ratio and elongation index were calculated using the formulae

$$\text{Elongation Ratio} = \frac{\text{Mean length of cooked grain}}{\text{Mean length of raw grain}}$$

$$\text{Elongation index} = \frac{\text{Mean length : width of cooked grain}}{\text{Mean length : width of raw grain}}$$

Solids Dispersed or Leaching Loss

Five grams pulses were cooked as above. Excess water left behind after removing the grains were put in pre weighed crucibles and oven dried at 100± 1□C and weight of the residue noted. Solids dispersed was calculated using the formula

$$\text{Solids dispersed} = \frac{\text{Weight of residue}}{\text{Weight of samples cooked}} \times 100$$

Swelling Capacity of Volume Expansion

Pulses were cooked as above. The seeds were drained and reweighed. THe final weight of drained seeds along with the leached solids were taken as the cooked weight. The swelling capacity was the difference between the raw weight and the cooked weight per 100 g seeds.

Water Uptake

To determine water uptake 5 g of the pulses were cooked as above. The grains were then separated from the excess water. Surface water of the cooked pulse was gently blotted with filter paper and the increased weight was noted. From this, water uptake in terms of g/100g pulse was calculated.

3.4 Estimation of nutrients and antinutritional constituents.

Pulses were powered and used for various chemical analysis. Estimations on various constituents of pulses were carried out using the following standard methods.

Constituents	Methods
Moisture	Raghuramulu *et al.*, 1983.
Ash	Raghuramulu *et al.*, 1983.
Crude fibre	Sadasivam and Manikan 1992.
Protein	Micro Kjeldhal method Hawk and Oser 1965.
Calcium	Atomic absorption spectroscopic method Raghuramulu *et al.*, 1983.
Iron	Wong's Method Raghuramulu *et al.*, 1983.
Arginine	Microbial assay Raghuramulu *et al.*, 1983.
Lysine	Microbial assay Raghuramulu *et al.*, 1983.
Methionine	Microbial assay Raghuramulu *et al.*, 1983.
Cystine	Microbial assay Raghuramulu *et al.*, 1983.
Oligosaccharides	Phenol sulphuric acid method.
Tannin	Folin-Denis method- Sadasivam and Manikan 1992.
Phytin	Sadasivam and Manikan 1992.
Trypsin Inhibitor	Sadasivam and Manikan 1992.
Total cholesterol	Carr - Drekker Method (1956).
Triglycerides	Van Handel and Zilversmit 1957.

3.5 Estimation of protein constituents and biological factors determining and quality of proteins through animal experiments.

Nature of protein of cowpea and greengram were assessed through polyacrylamide gel (PAGE) electrophoresis.

Adequacy of dietary proteins were determined by the quantity and their nutritional quality. Three basic parameters that indicate the nutritional quality of a protein are the percentage of the Essential Amino Acids (EAA) that are present in the protein, digestibility of the amino acids that have been released from the protein via digestion and the bio availability of the EAA released during protein digestion. To predict protein nutritional quality, the above parameters were measured either directly or indirectly.

Chemical Score

Chemical score is the ratio of the most limiting amino acid in the test proteins to the same amino acid in the egg protein and is expressed as percentage. Chemical score gives an indication of the protein quality. But this technique does not take into account the digestibility of the protein or the bioavailability of the amino acids in a protein and therefore does not accurately predict the nutritional quality. hence animal experiments were also conducted.

Animal Experiments

Animal experiments were conducted to find out Food Efficiency Ratio (FER), Protein Efficiency ratio (PER), Digestibility Coefficient (DC), Biological Value (BV) and Net Protein Utilization (NPU). Composition of diet used for the experiments in the study are presented in Table 1 and 2.

This experiments was conducted using weanling albino rats of 28 days old weighing 29±4g, over a period of 28 days. The animals were housed in individual cages and fed daily with weighed amounts of the respective diet mixtures at 10 per cent protein level. Food and

water were given *ad libitum*. Records of food intake and weight gain were maintained. The Feed Efficiency Ratio (FER) and Protein Efficiency Ratio (PER) were calculated using the following formulae.

$$\text{Feed Efficiency Ratio} = \frac{\text{Gain in body weight (g)}}{\text{Food intake (g)}}$$

$$\text{Protein Efficiency Ratio} = \frac{\text{Gain in body weight (g)}}{\text{Protein intake (g)}}$$

Table 1 Composition of diets used for various animal

experiments.- Ingredients (g)	Experimental diet	Control diet	Stock diet	Non Protein diet
Starch	42	74	57	84
Casein	-	10	27	-
Pulses	42	-	-	-
Mineral mixture	5	5	5	5
Vitamin mixture	2	2	2	2
Ground nut oil	9	9	9	9

Nitrogen balance

Nitrogen balance study was conducted on 10 groups of six adult male rats (90-100 days old). Each group was fed a non-protein diet for one week and after a four days rest period on stock diet, they were fed on experimental diets for one week. The feeding was *ad libitum*. Record of food intake was kept every day. Since the first three days of each period were considered as the preparatory and adjustment period, collection of urine and faeces was confined to the remaining four days of each period. Urine and faeces were analysed for nitrogen content and the values for Net Protein Utilization (NPU), Biological Value (BV) and Digestibility Coefficient (DC) were calculated using the following formulae.

$$\text{Digestibility Coefficient} = \frac{\text{Nitrogen intake - (Nitrogen in faeces - Endogenous faecal Nitrogen}}{\text{Nitrogen intake}} \times 100$$

$$DC = \frac{In - (Fn - Fe)}{In} \times 100$$

$$\text{Biological Value} = \frac{\text{Nitrogen digested - Nitrogen lost in metabolism}}{\text{Nitrogen digested}} \times 100$$

$$BV = \frac{In - (Fn - Fe) - (Un - Ue)}{In - (Fn - Fe)} \times 100$$

In - Food nitrogen intake

Fn - Faecal nitrogen on diet

Fe - Faecal nitrogen on protein free diet

Un - Urinary nitrogen on diet

Ue - Urinary nitrogen on protein free diet

$$\text{Net protein utilisation} = \frac{BV \times DC}{100}$$

3.6 Assessment of hypocholesterolemic effect of pulses.

Lysine : Arginine ratio of pulses was a major criterion for selecting variety for hypocholesterolemic study. Among the different varieties tested (cowpea and greengram) Kanakamany which had the optimum lysine:arginine ratio was selected to study its hypocholesterolemic effect.

Hypocholesterolemic effect of Kanakamany was assessed through animal experiments. Young male albino rats (average weight 100g) were divided into 3 groups of 10 rats each.

They were fed for 100 days with the following diets.

Group I	Normal diet
Group II	High fat high cholesterol diet with 16 per cent casein protein.
Group III	High fat high cholesterol diet with 16 per cent Kanakamany protein.

Composition of the different diets are presented in Table 2

Table 2 Percentage Composition of different diets

Ingredients	Group I	Group II	Group III-
Starch	70	57.50	06.67
Casein	16	16.00	-
Kanakamany	-	-	66.67
Ground nut oil	05	15.00	15.00
Salt mixture	04	04.00	04.00
Vitamin mixture	01	01.00	01.00
Cellulose powder	04	04.00	04.00
Cholesterol	-	04.00	02.00
Sodium chloride	-	00.50	00.50

The animals were maintained on the respective diets for 100 days. Body weight of the animals were recorded at every month and before slaughter. At the end of the period, the rats were fasted overnight, stunned by a blow on the back of the neck and killed by decapitation. Serum, liver and faeces were collected for lipid estimation. Cholesterol and triglyceride content in serum, liver and faecal sterols were estimated using standard methods.

3.7 Assessment of the influence of different processing and cooking methods on the various quality parameters of pulses.

Processing is a precondition for the consumption of legumes. They are processed and consumed in a variety of forms depending on cultural and taste preferences. The most common domestic methods of processing of legumes include soaking, ordinary cooking, pressure cooking and sprouting. Earlier studies revealed that boiling is the common method used for preparing greengram and cowpea, followed by pressure cooking. Soaking pulses is a common practice adopted to reduce the cooking time. It was reported that domestic processing and cooking methods could reduce the antinutrients in pulses and germination seemed to have a marked effect in lowering antinutrients. This meeds to be investigated and with this perspective in mind, the second experiment was planned to determine the changes in nutrients and antinutrients during processing and cooking methods.

Based on the quality cowpea variety 'Kanakamany' and greengram variety 'Mg 161' were selected to study the influence of processing and cooking.

Processing and cooking methods:

Different cooking methods selected were,

Cooking by boiling methods:

Pulses were cooked until done.

Soaking and cooking by boiling:

Pulses were soaked in distilled water for 12 hours and cooked by boiling.

Steaming:

Cowpea and greengram seeds were cooked in idli steamer until soft.

Soaking and Steaming:

Pulses were soaked in distilled water for 12 hours and steamed until soft.

Cooking under pressure:

Pulses were cooked until soft in pressure cooker.

Germination

Pulses were soaked in distilled water for 12 hours and kept bundled in a piece of moist cloth for sprouting for 24 hours.

Germination and steaming

Pulses were germination as above and cooked by steaming. Pulses, cooked by different methods and in combination with treatments prior to cooking were analysed to find out the influence of processing on the cooking, nutritional and antinutritional factors. Protein, calcium, iron, tannin, phytin, trypsin inhibitor and oligosaccharides were estimated using the standard methods listed under chemical analysis. Cooking characteristics such as cooking time, water uptake, swelling index and solid disperson were also assessed.

3.8 Statistical analysis

Analysis of variance was done for all the parameters like physical and cooking characteristics and nutritional and antinutritional constituents. Correlation matrix was also worked out to study the association among the parameters. Metroglyph and index score method was used to identify the superior variety and better processing methods.

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

This chapter includes a comprehensive information on varieties of cowpea and greengram with reference to their physical characteristics, cooking qualities, nutritional composition antinutritional factors, protein quality parameters and hypocholesterolemic effect based on the investigations carried out in the study.

4.1 Pulse cultivation and consumption pattern of selected farm families (Tables 3 and 4)

Cowpea and greengram were selected for the study based on the salient findings of a survey conducted among 50 farm families in the major pulse cultivating areas of Kerala viz; Thrissur, Kollam and Palakkad districts.

As per the findings of the survey, cowpea was cultivated by maximum number of families (75.80 per cent) survived while greengram was cultivated by only a lesser number (24 per cent) of families (Table 3).

Assessment of the pulse consumption pattern among these families revealed that 98.20 per cent of the families were using cowpea and greengram in their meals. Frequency of use of various pulses by these families were measured using a 5 point scale.

Table 3 Distribution of farm families based on their pulse cultivation pattern.-

Pulses	Details of families	
Greengram	120	(24.00)
Blackgram	167	(33.40)
Redgram	66	(13.20)
Cowpea	379	(75.80)
Horsegram	17	(03.40)
Bengalgram	5	(01.00)
Greenpeas	47	(09.40)
Soyabean	16	(03.20)

Figures in parenthesis indicate percentage.

Mean score obtained for each pulses on the basis of frequency of use, reveals that there was difference in the frequency of use of different pulse (Table 4). The mean score and mean per cent were highest for blackgram (3.03 and 60.64 per cent) and was lowest for horsegram (0.58 and 11.64 per cent); greengram (1.92 and 38.44 per cent) and cowpea (1.98 and 39.68 per cent) obtained almost similar score. Even though the frequency of use of greengram and cowpea were lower than black gram they were used in all the major meals whereas blackgram was used mainly for breakfast preparations.

Survey results further revealed that greengram (36.80 to 43.00 per cent) was the most preferred pulse followed by cowpea (20.40 to 27.00 per cent) among all the age groups in the families.

Table 4 Frequency Score obtained for various pulses-

Pulses	Mean score	Mean per cent scoreover total score
Greengram	1.92	38.44
Blackgram	3.03	60.64
Redgram	1.50	29.96
Cowpea	1.98	39.68
Horsegram	0.58	11.64
Bengalgram	1.36	27.12
Greenpeas	1.19	22.36

Pulses, being a rich source of protein were observed to be used for preparing weaning foods also, by the farm families (66.60) per cent) and among them 38.60 per cent were using greengram for this purpose while cowpea was used by only very few families (10.60 per cent).

Review of Kerala Agricultural University research reports during 1980-92 revealed that among pulses, more work was done on cowpea and greengram. Considering all these factors greengram and cowpea were selected for the present study. Five varieties each of

greengram and cowpea evolved and recommended by Kerala Agricultural University were used for quality assessment.

4.2 Assessment of Physical characteristics of cowpea and greengram (Tables 5 and 6)

Physical characteristics of pulses are important quality parameters for consumers and these characteristics collectively are referred as consumer preferences as reported by Umaid Singh *et al.* (1993). In the present study the physical characteristics viz, length : width ratio, grain weight, volume and density were assessed.

There were great variation as far as size and shape of the seeds varying from spherical to an almost cylindrical. Seed coat colour was also variable, from white to black going through all colours, spotted or uniform. In pulses seed size, shape and colour, needs to be in accordance with consumer demands. For this reason there are specific cultivars popular for different regions in the country.

The physical characteristics of cowpea varieties assessed are presented in Table 5.

As indicated in the Table, among the five varieties selected two varieties viz; V 118 and Pournami were cream coloured with light brown and black eye respectively. C 152 and Kozhinjipayar were light buff coloured and Kanakamany was maroon in colour.

As revealed in Table 5 there was significant difference in the physical characteristics of different varieties of cowpea. Length of the grains ranged from 06.00 to 07.87 cm for 10 grains. Among the different varieties studied, length of Pournami (07.87 cm) was significantly higher than other varieties while that of Kozhinjipayar (06.00 cm) was ignificantly lower. Length of other three varieties were comparable.

Width of cowpea varieties ranged from 04.73 to 05.40 cm. Width of Kanakamany (05.40 cm) was significantly greater than other varieties and V 118 obtained the lowest width (04.73 cm) which was significantly lower than other varieties. There was no significant difference in width among other three varieties viz; C 152, Kozhinjipayar and Pournami.

Table 5 Physical characteristics of cowpea varieties

No.	Varieties	Length cm	Width cm	Length width ratio	100 grain weight (g)	100 grain volume (ml)	seed density g/ml
V_1	C 152	06.93	04.93	01.41	10.28	08.60	01.22
V_2	V 118	07.20	04.73	01.52	08.23	07.17	01.15
V_3	Pournami	07.87	05.00	01.57	11.10	09.00	01.05
V_4	Kozhinji-payar	06.00	04.93	01.22	10.19	08.67	01.15
V_5	Kanaka-many	06.97	05.40	01.29	12.45	11.33	01.22
	F	33.681**	08.185**	27.806**	38.517**	18.578**	00.361
	SE	00.115	00.086	00.028	00.248	00.349	00.114
	CD	03.364	00.270	00.090	00.780	01.101	—

**** Significant at 5 per cent level**

Length	V_3	V_2	V_5	V_1	V_4
Width	V_5	V_3	V_4	V_1	V_2
L:W Ratio	V_3	V_2	V_1	V_5	V_4
Grain weight	V_5	V_3	V_1	V_4	V_2
Grain volume	V_5	V_3	V_4	V_1	V_2
Density	V_5	V_1	V_2	V_4	V_3

Based on the data on length and width, and length: width ratio of the grain was worked out.

Length:Width ratio of cowpea varieties ranged from 01.22 to 01.57. The ratio was maximum for Pournami (01.57) followed byV 118 (01.52) which were not significantly different. The minimum length : width ratio was obtained for Kozhinjipayar (01.22) followed by Kanakamany (01.99) and the length : width ratio of these two grains were not significantly different and both were significantly lower when compared with other varieties.

Though length and width showed wide variations, length : width ratio did not show much difference among varieties. Grain weight is an indicator of yield and hence it is important for the farmers. Grain weight (randomly selected 100 grains) of cowpea varieties ranged from 08.24 g in V 118 to 12.45 g in Kanakamany. Grain weight was significantly higher for Kanakamany (12.45 g) and was significantly lower for V 118 (08.23 g). Grain weight of Pournami was significantly higher than other varieties except Kanakamany while the weight of C 152 (10.28 g) and Kozhinjipayar (10.19 g) were comparable.

Grain volume (randomly selected 100 grain) of cowpea varieties ranged from 8.67 ml to 11.33 ml. The highest grain volume wa obtained for Kanakamany (11.33 ml) which was significantly higher than other varieties, while that of V 118 (08.67 ml) was significantly lower. Difference in grain volume was not significant among Pournami, Kozhinjipayar and C 152.

Seed density was calculated from weight and volume. The density of cowpea varieties ranged from 01.05 (Pournami) to 1.22 (Kanakamany and C 152). Seed density of Kanakamany and C 152 were significantly higher than Pournami (01.05) and that of V 118 and Kozhinjipayar were 01.15.

Variation in grain weight, volume and density of cowpea varieties studied may be due to the genetic variability. Sunday and Uzodima (1993) also reported significant variation in physical characteristics such as length, width, weight, volume and density in Nigerian cowpea varieties. Physical characteristics influence cooking characteristics,

nutritional composition and antinutritional factors in pulses. Consumers prefer grains with higher weight, volume and density.

Cowpea varieties were ranked in the descending order based on their physical characteristics. As revealed from the ranking order, Kanakamany ranked first in width, weight, volume and density, ranked third in length and fourth in length:width ratio. Pournami ranked first in length and length width ratio and second in width, weight and volume. Pournami ranked fifth in density. V 118 ranked second in length, length:width ratio and third in seed density. Further V 118 secured lowest rank in width, weight and volume. C 152 ranked second in density and third in length:width ratio and weight and fourth in length, width and volume. Kozhinjipayar obtained only third rank for width and volume and fourth in weight and density. Kozhinjipayar was lowest in length and length:width ratio.

Physical characteristics of greengram varieties are presented in Table 6.

Length of the grains ranged from 04.13 to 04.33 cm; M 3 and Pusa 8793 obtained the highest length (04.33 cm) which was significantly higher than that of Mg 161 and Pusa Baisakhi (04.13 cm), while the length of Co 2 (04.29 cm) was comparable with all the varieties studied. The maximum grain width of 3.23 cm was recorded for Pusa 8793 and the minimum was for Pusa Baisakhi (03.03 cm). Among the five greengram varieties there was no significant Varietal variation. As indicated in the table there was no significant Varietal variation in length: width ratio also. The length width ratio ranged from 01.29 for Mg 161 to 01.38 for M 3.

Hundred grain weight of greengram varieties ranged from 20.84 to 03.18 and there was significant Varietal difference. Pusa 8793 (03.18 g) was comparable with Co 2 (03.15 g) and significantly higher than other three varieties.

As revealed from the results, there was no significant variation in grain volume among greengram varieties. Grain volume ranged from 2.50 ml in Mg 161, Pusa 8793 and Pusa Baisakhi to 2.83 ml in M3.

Table 6 Physical characteristics of greengram varieties

No.	Varieties	Length cm	Width cm	Length width ratio	100 grain weight (g)	100 grain volume (ml)	seed density g/ml
V_1	Mg 161	04.13	03.20	01.29	02.84	02.50	01.13
V_2	M 3	04.33	03.13	01.38	03.06	02.83	01.09
V_3	Co 2	04.20	03.17	01.34	03.15	02.67	01.19
V_4	Pusa 8793	04.33	03.23	01.34	03.18	02.50	01.27
V_5	Pusa Baisakhi	04.13	03.03	01.36	02.84	02.50	01.13
	F	04.599 *	01.204	02.961	22.490 **	01.999	02.93
	SE	00.047	00.069	00.020	00.035	00.105	00.41
	CD	00.149	—	—	00.109	—	—

**** Significant at 5 per cent level**
*** Significant at 1 per cent level**

Length	V_2	V_4	V_3	V_1	V_5
Width	V_4	V_1	V_3	V_2	V_5
L:W Ratio	V_2	V_5	V_4	V_3	V_1
100 grain-weight	V_4	V_3	V_2	V_5	V_1
100 grain-volume	V_2	V_3	V_1	V_4	V_5
Seed Density	V_5	V_1	V_2	V_3	V_4

Seed density of greengram varieties ranged from 01.09 (M 3) to 01.27 (Pusa 8793). There was significant variation among varieties in density.

As revealed from the results, there was no significant Varietal variation in the physical characteristics of greengram varieties except for length and grain weight. Significant Varietal variation in seed size among greengram varieties are reported by Rao *et al.* (1987) and Chitra *et al.* (1995). Significant variation in length and weight in the present study also indicated Varietal variation in size of grains.

Greengram varieties were ranked in the descending order based on their physical characteristics. M 3 ranked first in length, length:width ratio and grain volume and third in width. Pusa 8793 was ranked first in width, and weight; and density second in length, third for length:width ratio and fourth in grain volume.

Among the various physical characteristics studies length:width ratio and seed density are found to be major determinants of the quality of pulses. Pulses with higher values for length : width ratio and seed density are found to be more acceptable among consumers. Among the five cowpea varieties studies length:width ratio was highest for Pournami while seed density was higher for Kanakamany and C 152. Among greengram varieties M 3 and Pusa 8793 obtained higher values for length:width ratio and seed density respectively.

4.3 Assessment of cooking qualities of cowpea and greengram (Tables 7 and 8).

Cooking qualities of grain legumes are important determinants of their quality and have been shown to be affected by Varietal difference (Longe 1983). Cooking qualities determined in this study were cooking time, water uptake, leaching loss, elongation ratio, elongation index and swelling index.

Cooking time can be defined as the time taken to cook the sample when put in excess boiling water. The grain were then separated and weighed to get water uptake or swelling

capacity. Excess water left behind was dried and weight of residue is expressed as solid dispersion or leaching loss. The percentage increase in volume after cooking is expressed as volume expansion or swelling index. Increase in length and width after cooking is used to calculated elongation ratio and elongation index.

It may not be wrong to say that cooking quality of any food article is primarily determined by its cooking time. One of the major constraints in the wide spread consumption of pulses, is the prolonged cooking or soaking time resulting in inconvenience to consumers, waste in valuable cooking fuel and significant reduction in nutrients. Higher water absorption and lower solid dispersion of cooked pulse helped to elevate their acceptability.

Elongation ratio, elongation index and volume expansion are other criteria assessed under cooking characteristics since the consumers prefer the grains which expands in dimensions or size and volume after cooking.

Perusal of the cooking characteristics of cowpea varieties revealed significant Varietal variation in cooking time, where as the variation in other characteristics were not statistically significant.

Cooking time of grain legumes are influenced by various factors such as type of grain and protein content as reported by Sood *et al.* (1991); and seed weight, volume swelling index and hydration capacity as observed by Williams *et al.* (1983).

Cooking time of cowpea varieties ranged from 47 minutes (Kanakamany) to 74 minutes (C 152). Cooking time of Kozhinjipayar was on par with Kanakamany and were significantly lower than other varieties. Cooking time was highest for C 152 and was not statistically different from Pournami and V 118.

Cooking time was lowest for Kanakamany which obtained highest weight and volume. In earlier studies cooking time of cowpea varieties are reported to vary between 29 and 37 minutes (Sunday and Uzodima, 1993) but longer cooking time was reported for various cowpea cultivars by Longe (1983), Demooy and Demooy, (1990) and Akingele *et al.*

Table 7 Cooking characteristics of cowpea varieties

No	Varieties	Cooking time minutes	Water uptake per cent	Volume expansion per cent	Leaching loss mgpercent	Elongation ratio	Elongation index
V_1	C 152	74.00	86.67	105.00	36.67	02.56	01.02
V_2	V 118	69.33	102.00	108.33	43.00	02.57	01.01
V_3	Pournami	68.14	104.00	117.67	49.00	02.56	01.02
V_4	Kozhinji-payar	52.00	96.67	98.00	49.00	02.55	01.02
V_5	Kanaka-many	47.00	98.67	105.00	38.33	02.57	01.02
	F	23.164**	02.125	001.158	01.127	00.798	00.619
	SE	02.439	04.626	006.642	05.445	00.011	00.008
	CD	07.684	-	-	-	-	-

** Significant at 5 per cent level

Cooking time	V_5	V_4	V_3	V_2	V_1
Water uptake	V_3	V_2	V_5	V_4	V_1
Volume expansion	V_3	V_2	V_1	V_5	V_4
Leaching loss	V_3	V_4	V_2	V_5	V_1
Elongation ratio	V_2	V_5	V_3	V_1	V_4
Elongation index	V_3	V_4	V_1	V_5	V_2

(1986). Kurian *et al.* (1972) have stated that cooking time of various grain legumes ranged from 30 minutes to one hour.

Water absorption of legumes has been shown to be influenced by seed coat structure and thickness, seed size, protein content, calcium content and initial moisture content (Sefa - Dedeh and Stanley, 1979; and Husu *et al.*, 1983). In this experiment, water uptake was found to be the highest in Pournami (104) and lowest in C 152 (86.67). Water uptake was significantly higher for Pournami when compared with other varieties except V 118. Among the varieties the difference in water uptake was not significant. In an experiment reported by Sunday and Uzodima (1993) for cowpea cultivars, the values for water uptake observed were with in the range of 77 to 123.50 per cent.

Volume expansion or swelling index of cowpea varieties ranged from 98.00 per cent in Kozhinjipayar to 117.67 per cent in Pournami. However, the difference among varieties was not significant.

Leaching loss or solids dispersion per cent of cowpea varieties varied from 36.67 mg per cent in C 152 to 49 mg per cent in Pournami and Kozhinjipayar and the difference among varieties was not significant. Sunday and Uzodima (1993) reported Varietal variation in leaching loss ranging from 33.00 to 94.00 mg per cent in cowpea.

Elongation ratio and elongation index are qualities which denote the increase in dimensions of the grain during cooking. As indicated in the Table, elongation ratio of cowpea varieties ranged from 02.57 in V 118 and Kanakamany, to 02.55 in Kozhinjipayar. However, the Varietal variation was not statistically significant. The lowest elongation index of 1.01 was recorded in V 118 and was 1.02 for other varieties.

Cowpea varieties are ranked in the descending order based on their cooking qualities. Pournami ranked first in water uptake, volume expansion, leaching loss and elongation index. For cooking time and elongation ratio Pournami ranked third. Kanakamany ranked first in cooking time with the lowest span, ranked second in elongation ratio, third in water uptake and fourth in volume expansion and leaching loss.

V 118 ranked first in volume expansion, second in water uptake and volume expansion, third, fourth and fifth rank respectively for leaching loss, cooking time and elongation index. Kozhinjipayar ranked second in cooking time, leaching lose and elongation index and fourth in water uptake and obtained lowest rank for volume expansion and elongation ratio. C 152 was third in volume expansion and elongation index and fourth in elongation ratio. C 152 ranked fifth in cooking time, water uptake and leaching loss.

Cooking characteristics of greengram varieties are presented in Table 8. Assessment of the data in Table 8 revealed that unlike cowpea, cooking characteristics of greengram varieties did not have significant Varietal variation except for leaching loss. Volume expansion obtained for greengram variety was highest for Co 2 followed by Mg 161 and M 3 and the lowest was recorded for Pusa 8793. Varietal variation was not statistically significant. There was significant Varietal variation in leaching loss or solid dispersion among greengram varieties. Leaching loss was highest for Pusa Baisakhi (63.67 mg per cent) and was lowest for Mg 161 (32.33 mg per cent). Leaching loss of Mg 161 and Pusa 8793 were comparable but were significantly higher than other varieties. Cooking time of greengram varieties ranged from 31.33 minutes in M 3 to 40.33 minutes for Pusa 8793. Among different greengram varieties the difference in cooking time was not statistically significant. In a study, cooking time for greengram was in the range of 27 to 49 minutes as reported by Vimala and Pushpamma (1987). Significant Varietal variation in cooking time was reported by Rao *et al.* (1978). In this experiment water uptake or swelling capacity of greengram was found to be lowest in Pusa 8793 (100 per cent) and was highest for Co 2 (118 per cent). Among different varieties the difference was not statistically significant.

Volume expansion or swelling index of the grains ranged from 113.33 per cent to 133.33 per cent. The highest volume was obtained for M 3 and Co 2 and were on par with Pusa Baisakhi which recorded the highest value.

Elongation ratio of greengram varieties ranged from 2.51 to 2.60. The higher value was obtained for Pusa Baisakhi and lowest for M 3 and the difference was not statistically significant. Elongation ratio obtained for other three varieties were also the same.

Table 8 Cooking characteristics of greengram varieites

No.	Varieties	Cooking time minutes	Water uptake per cent	Volume expansion per cent	Leaching loss mg percent	Elongation ratio	Elongation index
V_1	Mg 161	34.13	105.67	130.00	32.33	02.58	01.01
V_2	M 3	31.33	105.33	130.00	55.67	02.51	00.99
V_3	Co 2	33.07	118.00	133.33	51.67	02.58	01.02
V_4	Pusa 8793	40.33	100.00	113.33	41.67	02.58	01.01
V_5	Pusa Baisakhi	32.11	113.00	115.33	63.67	02.60	01.05
	F	02.343	001.807	000.590	04.236*	01.675	01.753
	SE	02.348	005.270	012.129	05.942	00.026	00.16
	CD	-	-	-	18.723	-	-

* Significant at 1 per cent level

Cooking time	V_2	V_5	V_3	V_1	V_4
Water uptake	V_3	V_5	V_1	V_2	V_4
Volume expansion	V_3	V_2	V_1	V_5	V_4
Leaching loss	V_3	V_2	V_3	V_4	V_1
Elongation ratio	V_5	V_3	V_4	V_1	V_2
Elongation index	V_5	V_3	V_4	V_1	V_2

Elongation index studied ranged from 0.99 (M 3) to 1.05 (Pusa Baisakhi) and the Varietal difference was significant.

Among the different factors studied under cooking characteristics, Varietal variation was significant for leaching loss alone in the case of greengram varieties. Greengram varieties are ranked in the descending order based on their cooking qualities. Cooking time was lowest in M3 and was ranked first. M 3 ranked second in volume expansion and leaching loss and fifth in elongation ratio and elongation index. Greengram variety, Pusa Baisakhi ranked first in leaching loss, elongation ratio and index and ranked second in cooking time and water uptake and fourth in volume expansion. Co 2 ranked first in water uptake and volume expansion and second in elongation ratio, third in cooking time and leaching loss. Mg 161 ranked third in water uptake and volume expansion and fourth in cooking time elongation index and elongation ratio. It secured lowest rank for leaching loss. Pusa 8793 ranked third in elongation ratio and elongation index and fourth in leaching loss. Pusa 8793 obtained lowest rank for cooking time, water uptake and volume expansion.

While assessing the cooking characteristics, it was observed that among cowpea varieties, only Pournami which has favorable physical characteristics was found to be superior in cooking qualities also. Kanakamany required lowest cooking time. However, in leaching loss, C 152 and for water uptake and volume expansion Pournami were found to have favorable values when compared to Kanakamany. Hence among the five varieties of cowpea studied Pournami can be considered as a better quality seed when physical characteristics and cooking characteristics are considered.

There was wide variation in cooking characteristics among greengram varieties. No association between physical characteristics and cooking characteristics was noticeable in greengram. Lowest cooking time was for M 3 and maximum volume expansion and water uptake were observed in Co 2, while the lowest leaching loss was in Mg 161. M3 with better physical characteristics and shortest cooking time, can be considered as the better variety, among the five samples.

Interrelationship between physical characteristics and cooking characteristics of the pulses.

Physical characteristics such as grain weight and volume are important quality parameters of grain. These factors are found to be directly associated with cooking time in chickpea, (Williams *et al.*, 1983) in cowpea (Sunday and Uzodima, 1993) and in lentils (Erskine *et al.*, 1985). In the present study in cowpea grain weight (-.5337*), volume (-.6578**) and width were negatively associated with cooking time while positive association with cooking time was found to be associated with width of the grain (.06953**).

Seed weight influences the solid dispersion (Sunday and Uzodema, 1993) and water uptake (Safa Dedeh and Stanley, 1972; Hsu *et al.*, 1983 and Deshpande *et al.*, 1984) which are important cooking qualities for the consumers. In the present study, volume expansion was found to have a positive association with length (.5996*) in cowpea and width (.5541*) and water uptake (.7038*) in greengram. But no association was observed between seed weight with water uptake and solid dispersion. The physical characteristics of the seeds appeared to be important for water absorption as found by Deshpande *et al.* (1984). Water absorption of legumes have been shown to be influenced by seed coat structure and thickness, seed size, helium size, protein content, calcium and initial moisture content (Sefa dedeh and Stanley 1979, and Hsu *et al.*, 1983). Water absorption was lower for larger seeds (Sunday and Uzodima, 1993) and was not related to cooking time (Longe, 1983 and Sunday and Uzodima, 1993). In the present study no relation was observed among water uptake, seed size and cooking time. In cowpea, cooking time was positively associated with length:width ratio (.7426**) and density (.6125*[8]).

4.4 Nutritional Composition of cowpea and greengram (Tables 9 and 10)

Food legumes predominate the diets of majority of the population in India and other developing countries due to the easy availability of different varieties of pulses at a comparatively reasonable cost. The nutrient composition of food legumes has certain

characteristic features which distinguish them from other major plant foods particularly cereals and tubers. The nutritional quality of pulse varieties depend upon the genetic and environmental factors.

The nutritional composition and quality of pulses were assessed through laboratory techniques and biological experiments. Chemical analysis of the grains were carried out to estimate different nutrients in pulses viz; ash, moisture, calcium, iron protein and crude fibre indifferent varieties.

Pulses occupy a prominent position in the diet as a rich source of proteins. Pulses are good sources of minerals needed for the development of body structure and capability of body functions. Calcium and iron are the most important elements essential for the formation of skeleton, tooth and blood. Fibre adds bulk to the diet and helps to increase transit of chyme in the gut. Fibre is also known to be associated with reduced incidence of coronary heart disease. Fibre may also have some adverse effects on nutrition by binding some trace metals and their absorption. Moisture content in pulses are important as it influences the nutrients density of the grain.

As revealed in Table 9 there was significant variation in the nutrient composition of cowpea varieties with reference to protein, calcium, iron, ash, fibre and moisture content.

Pulses are widely accepted as a good source of protein. But breeding techniques are to be adopted to improve the protein content in pulses since these crops are the best and cheap source of proteins in the vegetarian diet. The results in the Table revealed a significant Varietal variation in the protein content. As reported a significant Varietal variation in the protein content. As reported by many workers the protein content is greatly influenced by environmental factors and genotypes.

The protein content of cowpea varieties studies ranged from 20.92 g per cent to 24.06 per cent. The highest protein content was observed in Kanakamany and was significantly higher than in other varieties except in Pournami. The protein content of Pournami (23.41 g per cent) was comparable with C 152 (22.78 g per cent). Protein content was minimum

Table 9 Nutrient composition of cowpea varieties

No.	Varie-ties	Protein g per cent	Calcium mg per cent	Iron mg per cent	Ash mg per cent	Crude fibre per cent	Moisture per cent	EMC S percent
V_1	C 152	22.78	238.33	10.40	03.77	05.55	08.53	103.33
V_2	V 118	21.85	214.00	07.23	05.10	06.60	09.53	098.00
V_3	Pournami	23.41	224.33	07.93	04.47	06.60	09.60	109.33
V_4	Kozhinji-payar	20.92	226.33	06.77	05.27	04.83	12.33	097.67
V_5	Kanaka-many	24.06	233.67	12.30	05.23	05.02	10.07	091.33
	F	14.427**	003.420	81.941**	268.244**	558.884**	118.040**	003.639*
	SE	00.328	004.699	00.260	00.039	003.576	000.130	003.543
	CD	01.032	-	00.818	00.124	000.113	000.410	011.165

** Significant at 5 per cent level
* Significant at 1 per cent level

Protein	V_5	V_3	V_1	V_2	V_4
Calcium	V_1	V_4	V_3	V_5	V_2
Iron	V_5	V_1	V_3	V_2	V_4
Ash	V_4	V_5	V_2	V_3	V_1
Crude Fibre	V_2	V_3	V_1	V_5	V_4
Moisture	V_4	V_5	V_3	V_2	V_1
EMC S per cent	V_3	V_1	V_2	V_4	V_5

for Kozhinjipayar (20.92 g) per cent) and it was on par with V 118 (21.85 per cent). Protein content of cowpea cultivars was reported to range from 20.90 to 25.80 per cent by Sunday and Uzodima (1993) and protein obtained for cowpea varieties in the present study was also within the range. Salunkhe *et al*. (1985); Habib *et al* (1989); Fashakin and Fasanya (1988) and Kachare (1988) have reported significant Varietal variation in protein content in cowpea.

Pulses contain relatively high amounts of inorganic nutrients like calcium and iron. Variation in the ash content of pulses may also be due to the difference in the individual constituents.

Calcium content in cowpea varieties ranged from 214.00 to 238.83 mg per cent and there was no significant Varietal difference among the pulses. Maximum calcium content was recorded in C 152 (238.33 mg per cent) and was minimum in V 118 (214 mg per cent). Cowpea varieties C 152 was superior than other varieties as far as the calcium content was concerned, but there was no significant Varietal difference in calcium content. But Fashakin and Fasanya (1988) reported significant Varietal variation in calcium content in pulses.

As revealed from Table 9 there was significant Varietal variation in iron content in cowpea varieties. The iron content ranged from 06.77 mg per cent in Kozhinjipayar to 12.30 per cent in Kanakamany. Iron content in Kanakamany and C 152 (10.40 mg per cent) were comparable but were significantly higher than other varieties. While iron content in Kozhinjipayar was on par with the iron content in V 118. V 118 and Pournami were comparable for iron. Significant Varietal variation in iron content was reported by Fashakin Fasanya (1988).

The maximum ash or mineral content was obtained for Kozhinjipayar (5.27 per cent) and the minimum was for C 152 (3.77 per cent). The ash content of Kozhinjipayar was on par with Kanakamany but were significantly higher than other varieties. Among other three varieties the difference was not significant.

The crude fibre content of pulses was higher than in cereals (NIN, 1986). Crude fibre content in cowpea varieties ranged from 4.83 to 6.60 per cent and the Varietal

difference was statistically significant. The highest crude fibre content was obtained for V 118 and Pournami (6.60 per cent) and was significantly higher than in other varieties. Kozhinjipayar recorded the lowest crude fibre content.

The moisture content of the grains ranged from 8.53 per cent in C 152 to 12.33 per cent in Kozhinjipayar. Moisture content of Kanakamany was on par with Kozhinjipayar but was significantly higher than other varieties. While the moisture content was significantly lower for C 152.Moisture content of V 118 and Pournami were comparable.

Equilibrated moisture content upon soaking (EMC S) ranged from 91.33 per cent (Kanakamany) to 109.33 per cent (Pournami). EMC S per cent of Pournami was significantly higher than other varieties where as that of Kanakamany was comparable with V 118 and Kozhinjipayar. EMC S per cent of C 152 was comparable with V 118 and Kozhinjipayar.

Cowpea varieties studied were ranked, based on the concentration of different nutrients in the descending order.

As clear from the ranking order, Kanakamany was superior as it ranked first in protein and iron content, as second for ash and moisture content, fourth for calcium and crude fibre and still lower rank for EMC S per cent. Eventhough Kanakamany is not superior in all the qualities studied it can be selected as the best pulses among the five varieties since it was significantly higher in protein and iron content.

Among the pulse varieties studied, C 152 was ranked first in calcium content, second in iron and EMC S per cent and third in protein and crude fibre with the lowest rank for moisture and ash content. Kozhinjipayar was ranked first for moisture and ash content, as second in calcium and lowest in iron, protein and crude fibre and third in EMC S per cent and ash. V 118 was ranked fourth in moisture, iron and protein and lowest in calcium. Pournami had the highest values for EMC S per cent, second for protein and crude fibre and was third in moisture, calcium and iron, and fourth in ash.

Table 10 Nutrient composition of greengram varieties

No.	Varie ties	Protein g per cent	Calcium mg per cent	Iron mg per cent	Ash mg per cent	Crude fibre per cent	Moisture per cent	EMC S per cent
V_1	Mg 161	23.86	261.33	12.63	03.73	07.55	10.27	91.67
V_2	M 3	20.16	277.33	05.30	04.73	06.07	08.39	95.67
V_3	Co 2	19.46	247.67	08.10	04.70	03.17	08.93	106.00
V_4	Pusa 8793	22.13	262.33	08.53	05.93	05.07	14.33	82.67
V_5	Pusa Baisakhi	19.05	250.33	11.97	03.87	05.05	09.87	96.33
	F	23.869**	007.469**	100.700**	870.063*	3859.489**	385.169**	168.693**
	SE	00.286	004.302	00.299	00.030	00.026	00.119	00.650
	CD	00.901	013.556	00.945	00.094	00.081	00.376	02.048

** Significant at 5 per cent level

Protein	V_4	V_1	V_2	V_3	V_5
Calcium	V_2	V_4	V_1	V_5	V_3
Iron	V_1	V_5	V_4	V_3	V_2
Ash	V_4	V_2	V_3	V_5	V_1
Crude Fibre	V_1	V_2	V_4	V_5	V_3
Moisture	V_4	V_1	V_5	V_3	V_2
EMC S per cent	V_3	V_5	V_2	V_1	V_4

There was significant Varietal variation in the nutrient content among greengram varieties (Table 10).

The moisture content of greengram varieties ranged from 08.39 to 14.33 per cent. Variation among varieties were statistically significant. The highest moisture content was recorded for Pusa 8793 (14.33 per cent) followed by Mg 161 (10.27 per cent) and the lowest was for M 3 (8.39 per cent). In the studies conducted by Sharma *et al.* (1991) the moisture content in greengram varieties ranged from 8.20 to 8.67 per cent.

Equilibrated moisture content upon soaking ranged from 91.67 per cent in Mg 161 to 106.00 per cent in Co 2. There was significant variation among varieties except between M 3 and Pusa Baisakhi.

There was significant Varietal variation in protein content among greengram varieties. The variety Pusa 8793 had maximum protein content of 22.13 per cent followed by Mg 161 (21.86 per cent) which were comparable. Pusa Baisakhi obtained the lowest protein content of 19.05 per cent followed by Co 2 (19.46) which was also comparable. According to Sharma *et al.* (1991); Chitra *et al.* (1995) and Suneetha Kumari *et al.* (1983) the protein content of greengram varied significantly. Crude fibre content in greengram varieties ranged from 03.17 per cent in Co 2 to 07.55 per cent in Mg 161. Protein content of Mg 161 (07.55 per cent) and M 3 (06.07 per cent) were significantly lower.

Calcium content was found to be highest (277.33 mg/100g) in M 3 and lowest (247.67 mg per cent) in Co 2. The difference in calcium content among other three varieties were comparable. Sharma *et al.* (1991) and Sood *et al.* (1982) reported significant variation in calcium content in greengram varieties.

Iron content in greengram varieties ranged from 5.30 to 12.63 mg. The highest iron content was obtained for Mg 161 (12.63 mg per cent) and it was on par only with Pusa Baisakhi (11.97 mg per cent) but was significantly higher than other varieties. M 3 obtained the lower value (5.30 per cent) which was significantly lower than all other varieties. Iron content of Co 2 (8.10 per cent) and Pusa 8793 (08.53 per cent) were comparable. Iron content

of greengram variety varied significantly as reported by Sharma *et al.* (1991) and Sood *et al.* (1982).

Ash content ranged from 3.73 to 5.93 per cent. Maximum concentration for ash content was observed for Pusa 8793 (5.93 per cent) and this was significantly higher than in other varieties. Minimum value was obtained for Mg 161 (3.73 per cent). Ash content of M3 and Co 2 were also found to be comparable. Variation in ash content may be due to variations in individual mineral composition of varieties.

Fibre content in Pusa 8793 (05.07 per cent) and Pusa Baisakhi (05.05 per cent) were comparable. Thus among the five varieties studied fibre content was comparable for two varieties only.

Assessment of the nutrient composition of greengram varieties revealed that there was significant Varietal variation in all the qualities studied.

Greengram varieties studied were ranked based on their nutrient composition. As revealed from the ranking order greengram variety Pusa 8793 was ranked first in moisture, ash and protein content and second for calcium. Pusa 8793 obtained third position for iron and crude fibre content and lowest in EMC S per cent mg 161 was observed to have highest value for iron and crude fibre and second for protein and moisture content, third for calcium, fourth for EMC S per cent and fifth for ash content. M3 variety was superior in calcium and second in ash and crude fibre and third in EMC S per cent and protein. It had lowest values for moisture and iron content. Variety Co 2 ranked first in EMC S per cent, third in ash and fourth in moisture, iron and protein content. Cowpea variety, Co 2, obtained lowest rank for calcium. While for iron, Mg 161 was significantly better than all other varieties.

Assessment of the nutritional quality of cowpea and greengram varieties revealed that there is significant Varietal variation in nutrients studied except for calcium.

Among the different varieties studied cowpea variety Kanakamany and greengram variety, Mg 161 can be selected as superior as far as the nutrient composition is considered.

Variation in the nutrient composition among varieties and species may be due to different reasons. Environmental factors and agricultural practices affect the chemical composition and nutritive value of food legumes.

Unlike physical and cooking characteristics, nutritional quality is not given due weightage as an important parameter influencing the acceptability of pulses, among farmers and consumers. Among the different nutrients studied in Cowpea varieties, Kanakamany was found to be superior in protein and iron content. While calcium content was highest in C 152. Pournami which was superior in physical and cooking characteristics was poor in nutritional quality when compared with Kanakamany and C 152 which were while assessing the physical, cooking and nutritional quality Kanakamany can be considered as the better variety among the cowpea varieties studied.

Among greengram varieties protein content was highest in Pusa 8793, iron in Mg 161 and calcium in M 3. Mg 161 was next to Pusa 8793 in protein content and had a comparatively better calcium content. Hence, while considering the nutritional and cooking quality, Mg 161 can be considered as better variety even though it is poor in major physical characteristics like weight and volume. Similarly variety M 3 which had better physical and cooking characteristics was observed to be poor in various nutrients.

Antinutritional factors (Tables 11 and 12)

Legumes are known to contain a number of antinutritional and toxic factors. One of the problems associated with the frequent use of pulses that they are hard to digest and become responsible for gas production in the intestine. The mechanism by which pulses promote gas formation is related to the action or microflora on the indigestible carbohydrate components of the pulses. These components are oligosaccharides which include raffinose, stacchyose and verbascose.

Antinutritional factors are undesirable chemical substances that are known to exert a deleterious effect when ingested by man. In pulses, these substances include phytic acid, trypsin inhibitors, flatus producing oligosaccharides and tannins which can cause adverse

physiological response or diminish the availability of certain nutrients. Legumes are good sources of protein, minerals and vitamins, however their efficient utilisation was affected due to the presence of antinutritional factors.

The role of polyphenolic compounds, loosely termed as tannin is important since it has influence on the bioavailability of nutrients. This is particularly important when pulses are consumed as whole grains. Seed coat of pulses especially dark coloured ones are reported to contain the highest proportion of polyphenols than light coloured pulses.

Tannins have been demonstrated to have a deleterious effect on growth by binding to dietary protein and lower the digestibility of dietary protein. Dietary tannins are reported to function as metabolic poisons (Hageman and Butler, 1991).

Phytic acid is one of the widespread occurents in legumes and is of significant nutritional interest. Phytic acid is known to lower the bioavailability of minerals and inhibits proteases and amylases which are involved in proteins digestion thus reduce the protein digestibility. Complexing between phytate and proteins has been reported for several pulse proteins and this might affect the protein digestibility and bioavailability. In addition, phytates are also known to form complexes with dietary essential minerals in legumes, rendering them poorly available to man.

Trypsin inhibitor may also lower the digestibility of dietary proteins. Trypsin inhibitors, when ingested in significant amounts disrupt the digestive process and may lead to undesirable physiological reactions.

Pulses are known to produce flatulence, which causes considerable inconvenience when consumed in large quantities. This characteristics, discouraged broader use of such low cost high protein foods. The specific factor or factors responsible for flatulence have not been established. However certain oligosaccharides, like raffinose, stacchyose and verbascose have been identified to be associated with the gas producing factor.

Antinutritional factors present in cowpea varieties revealed that tannic acid content in cowpea varieties ranged from 180 mg per cent to 538 mg per cent. Tannic acid content

was highest in Kanakamany (537 mg per cent) followed by C 152 and Kozhinjipayar and all the three varieties were comparable. Tannic acid content was lowest in V 118 followed by Pournami and the difference in tannic acid content between these two varieties were significant and were significantly lower than other varieties. Purie *et al.* (1980) analyzed ten varieties of cowpea and found that the average tannin was 0.07 mg per cent. Phytic acid contents of cowpea varieties ranged from 328.67 mg per cent to 423.33 mg per cent. Phytic acid content was highest in Kozhinjipayar and was significantly higher than other varieties. The variety V 118 was found to contain a significantly lower phytic acid content. Phytic acid content in Pournami was comparable with Kanakamany which was on par with C 152.

Trypsin inhibitor activity of C 152 variety (44.18 TIU/mg sample) was found to be significantly higher than other varieties. While in V 118, trypsin inhibitor activity was significantly lower (29.26 TIU/mg sample) when compared with other varieties. Trypsin inhibitor activity of Pournami was on par with Kanakamany. Kanakamany was comparable to Kozhinjipayar.

There is little available information on the presence or absence of other undesirable components such as oligosaccharides which are reported to cause flatulence and influence digestibility of starch.

Oligosaccharides such as raffinose, stachyose and verbascose content of cowpea varieties were assessed and the results revealed that there was significant Varietal variation.

Raffinose content in cowpea varieties ranged from 0.42 to 0.67 g per cent. Raffinose content was significantly higher in V 118 (0.67 g per cent) and was significantly lower in C 152 when compared with other varieties. Raffinose content in Pournami was comparable with Kanakamany which was on par with Kozhinjipayar.

In cowpea varieties stachyose content ranged from 02.00 to 03.17 g per cent. Stachyose content was highest in Pournami (03.17 g per cent) and was on par with Kanakamany (2.90 g per cent). Lower stachyose content was recorded in Kozhinjipayar (2.00 g per cent) and was comparable with C 152. Stachyose content in Kanakamany was comparable with V 118 and V 118 on par with C 152.

Verbascose content in cowpea varieties ranged from 3.00 to 3.80 g per cent. Verbascose content was highest in Kanakamany followed by V 118 and Pournami and difference in verbascose content was not significant. Lowest verbascose content was found in Kozhinjipayar and was comparable with C 152 but were significantly lower than the other four varieties.

Assessment of the antinutritional factors in cowpea varieties revealed that there was significant Varietal difference. Antinutritional factors like tannic acid, phytic acid, and trypsin inhibitor were significantly lower in V 118 and hence this cowpea variety can be considered as nutritionally superior than other varieties as far as antinutritional factors are concerned. But the oligosaccharides content was higher in this variety. Kozhinjipayar was found to contain a significantly lower stachyose and verbascose content followed by C 152. Raffinose content was lowest in C 152 followed by Kozhinjipayar but the difference was significant. Cowpea varieties such as V 118, Kozhinjipayar and C 152 were found to contain lower oligosaccharides when compared with other varieties.

Tannic acid content of greengram varieties ranged from 310 mg to 400 mg per cent. Tannic acid content was significantly lower in M 3 (310 mg per cent) and this was comparable with Mg 161 (316.67 mg per cent). Highest tannin acid content was recorded in Co 2 (400 mg per cent) and this was on par with Pusa 8793 and significantly higher than other varieties.

As recorded in earlier studies, several environmental factors like climatic conditions, location, irrigation, fertilizer, soil type and growing season may influence the phytic acid in grain legumes (Reddy *et al.* 1982, Bressani and Nahapetian 1977 and Miller *et al.* 1980).

Phytic acid content ranged from 201.33 mg per cent in Co 2 to 265.33 mg per cent in Pusa 8793. Phytic acid content in Pusa 8793 and Pusa Baisakhi were comparable. Co 2 was comparable with Mg 161 in phytic acid content. Greengram variety M 3 was comparable with Pusa Baisakhi and Mg 161.

Table 11 Antinutritional factors in cowpea varieties

No.	Varieties	Tannic acid mg per cent	Phytic acid mg per cent	Trypsin inhibitor TIU/mg	Raffinose g per cent	Stachyose g per cent	Verbascose g per cent
V_1	C 152	522.33	366.33	44.18	00.42	02.27	03.10
V_2	V 118	180.00	328.67	29.26	00.67	02.63	03.60
V_3	Pournami	236.67	389.67	40.36	00.51	03.17	03.50
V_4	Kozhinji-payar	520.00	423.33	36.49	00.45	02.00	03.00
V_5	Kanaka-mony	538.00	387.33	38.48	00.48	02.90	03.82
	F	603.408**	24.00**	54.917**	84.166**	15.053**	09.583**
	SE	07.155	07.102	00.746	00.010	00.121	00.110
	CD	22.546	22.378	02.352	00.033	00.382	00.345

** Significant at 5 per cent level

Tannic acid	V_2	V_3	V_4	V_1	V_5
Phytic acid	V_2	V_1	V_5	V_3	V_4
Trypsin inhibitor	V_2	V_4	V_5	V_3	V_1
Raffinose	V_1	V_4	V_5	V_3	V_2
Stachyose	V_4	V_1	V_2	V_5	V_3
Verbascose	V_4	V_1	V_3	V_2	V_5

Trypsin inhibitor activity of the greengram varieties ranged from 55.74 to 97.71 TIU/mg. Trypsin inhibitor activity was found to be significantly lower in Mg 161 and was on par with Pusa 8793. Trypsin inhibitor activity was highest in Co 2 followed by M 3 and Pusa Baisakhi and the differences among varieties were statistically significant.

As indicated in the Table, there was significant Varietal variation in raffinose content among greengram varieties. Raffinose content was highest in Mg 161 and this was significantly higher than other varieties. Pusa 8793 was found to have a significantly lower raffinose content. Raffinose content of Co 2 was comparable with Pusa Baisakhi and M3.

Stachyose content in greengram varieties ranged from 0.95 to 2.03 per cent. Highest stachyose content was obtained for Pusa Baisakhi followed by M3 and Mg 161. However the difference between the varieties was not significant. Co 2 obtained the lowest stachyose content followed by Pusa 8793 and the stachyose content in these varieties were significantly lower than other varieties.

Verbascose content of greengram varieties ranged from 3.10 to 3.77 g per cent. Verbascose content was highest in Co 2 and was comparable with that of Pusa 8793. Among the greengram varieties studied, verbascose content was lowest in M 3 and was on par with Pusa Baisakhi and Mg 161.

Perusal of the results in Table 12 revealed that there was significant Varietal variation in the concentration of antinutritional factors and these factors alone cannot be considered to select a superior variety since the content of these different antinutritional factors varied from one variety to another.

M 3 was superior as it contained less amount of tannic acid and verbascose and ranked second in raffinose content where as Co 2 was found to contain minimum phytic acid stachyose. Mg 161 ranked first for its trypsin inhibitor activity and second for its tannic acid and phytic acid content. Pusa 8793 contained the lowest concentration of raffinose while trypsin inhibitor activity, stachyose and verbascose content were considerably higher.

Table 12 Antinutritional factors in greengram varieties

No.	Varieties	Tannic acid mg per cent	Phytic acid mg per cent	Trypsin inhibitor TIU/mg	Raffinose g per cent	Stachyose g per cent	Verbascose g per cent
V_1	Mg 161	316.67	209.67	55.74	00.71	01.77	03.47
V_2	M 3	310.00	230.67	85.60	00.58	01.80	03.10
V_3	Co 2	400.00	201.33	97.71	00.61	00.95	03.77
V_4	Pusa 8793	390.00	265.33	57.17	00.41	01.30	03.27
V_5	Pusa Baisakhi	340.00	254.67	69.48	00.63	02.03	03.57
	F	22.839**	012.609**	660.828**	103.676**	19.196**	07.035**
	SE	08.692	007.796	00.709	00.011	00.010	00.098
	CD	27.388	024.564	02.235	00.035	00.314	00.308

** Significant at 5 per cent level

Tannic acid	V_2	V_1	V_5	V_4	V_3
Phytic acid	V_3	V_1	V_2	V_5	V_4
Trypsin inhibitor	V_1	V_4	V_5	V_2	V_3
Raffinose	V_4	V_2	V_3	V_5	V_1
Stachyose	V_3	V_4	V_1	V_2	V_5
Verbascose	V_2	V_4	V_1	V_5	V_3

A general assessment of all the quality parameters studied so far revealed that, among cowpea varieties V 118 was lowest in tannic acid, phytic acid and trypsin inhibitor content but was not superior in their physical, cooking and nutritional qualities. Similarly flatus producing oligosaccharides, stachyose and verbascose were lowest in Kozhinjipayar but this variety was not superior in any other quality parameters studied. Raffinose content was lowest in C 152.

Thus among the cowpea varieties studied Kanakamany, C 152 and Pournami which were better in physical, cooking and nutritional qualities were having a higher concentration of antinutritional factors.

Assessment of the antinutritional factors in greengram varieties revealed that tannin and verbascose content were lowest in M 3 where as phytin and stachyose were minimum in Co 2. Mg 161 and Pusa 8793 were lowest in trypsin inhibitor and raffinose.

A general assessment of all the quality parameters studied so far revealed that cowpea variety Kanakamany and greengram variety Mg 161, can be considered better for physical characteristics, cooking characteristics and nutrient composition, even though they have higher concentration of antinutritional factors.

Among the various nutrients present in pulses, protein and minerals are the major ones affected by antinutritional factors like tannin, phytin and trypsin inhibitor. Pulses are always recommended as a protein rich food, for vegetarians. Presence of antinutritional constituents such as phytic acid, tannin and trypsin inhibitor result in low protein digestibility and hinder the efficient utilization of protein. Phytic acid hinder protein digestion by inhibiting proteolytic enzymes and by forming complexes with protein. Tannin decreases protein digestibility by making protein unavailable or by inhibiting digestive enzymes and increasing faecal nitrogen. Trypsin inhibitor reduces protein digestibility, by hindering the proteolytic enzyme trypsin. An illustration was attempted to workout the distribution of protein and antinutritional factors in different varieties of cowpea and greengram (Fig 1 and 2).

Fig 1 Relation between protein and antinutritional constituents in cowpea varieties

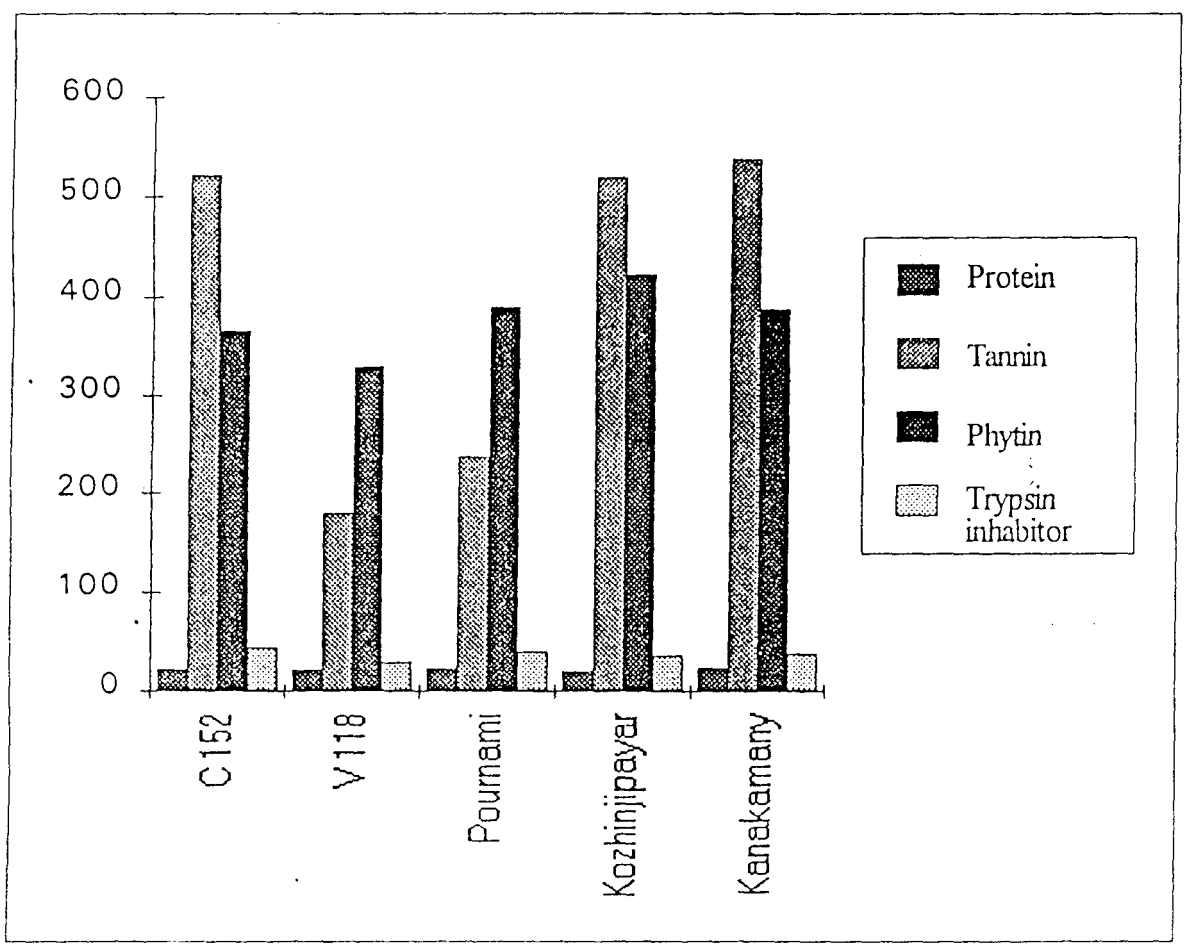
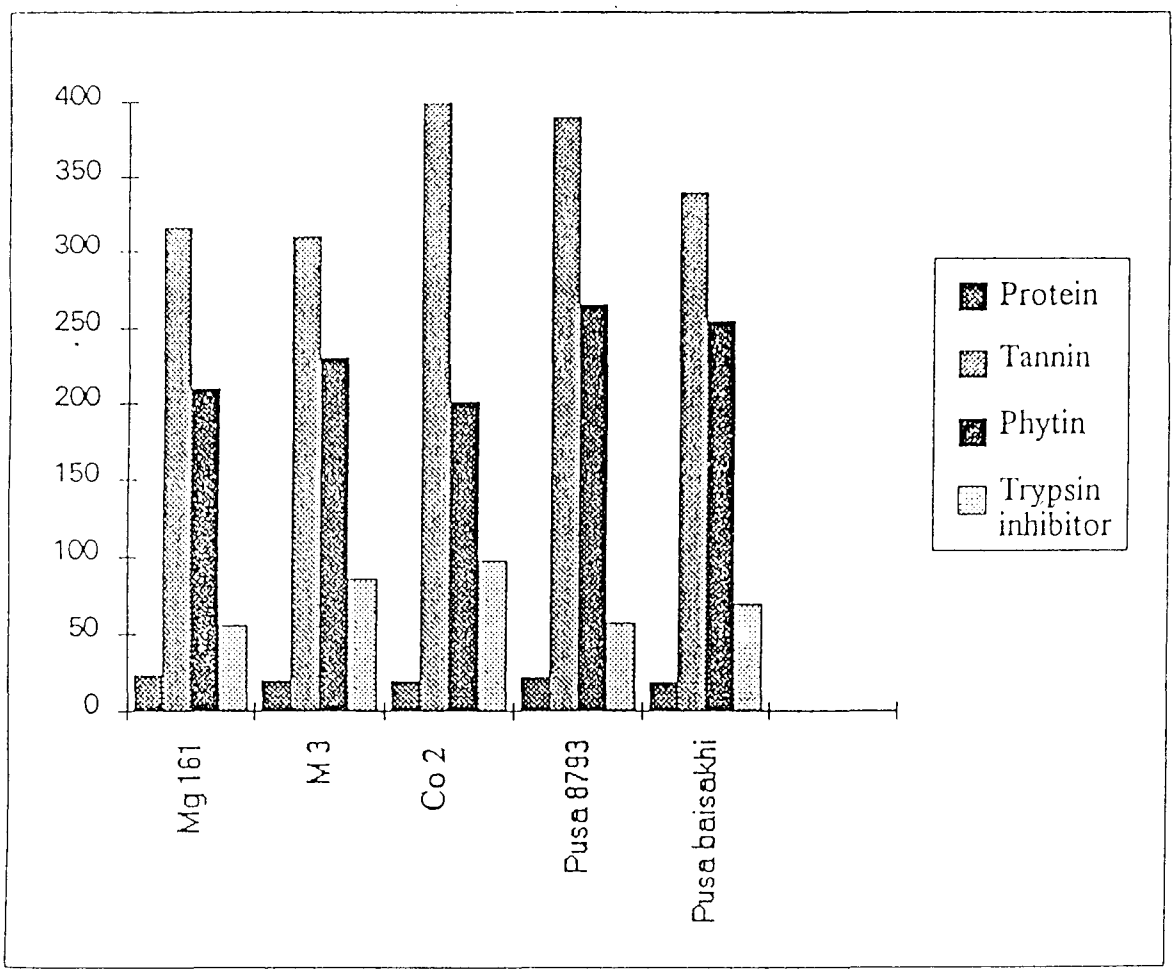


Fig 2 **Relation between protein and antinutritional constituents in green gram varieties**



As revealed from the graph among the five Kanakamany varieties studied protein content was highest in Kanakamany which contains the highest concentration of tannic acid also. However variation in tannin content of different varieties were not in proportion to the concentration of protein. Pournami with a comparatively higher protein content was found to have a lower concentration of tannic acid. As clear from the graph there was no association between protein content and the concentration of phytin for trypsin inhibitor in Kanakamany varieties. Antinutritional factors as well as protein content were comparatively lower in V118. C152 with better protein content and kozhinjipayar with lowest protein content were more or less same in antinutritional constituents.

In greengram varieties also there was no association between protein content and the concentration of protein inhibitors like tannin, phytin and trypsin inhibitor. Protein content was highest in Pusa 8793 which contain highest concentration of phytin and comparatively high in tannin but trypsin inhibitor was minimum. Pusa Baisakhi with lowest protein content was also comparatively high in phytin and moderate in tannin and trypsin inhibitor content. Mg 161 with higher protein content was lower in antinutritional factors. Co 2 with a comparatively lower protein content was highest in tannin and trypsin inhibitor but was lowest in phytin content. M 3 with moderate concentration of protein was comparatively lower in tannin and phytin but was higher in trypsin inhibitor.

4.5 Protein quality parameters (Tables 13 to 16)

True heterogenicity of pulse protein can be estimated by electrophoresis. In electrophoretic procedure, pulse proteins are separated on the basis of their charge in response to a driving force and their retardation due to adsorption to a sieving effect of a gel support. The components in seed protein, characteristics of the species, are separated by polyacrylamide gel electrophoresis, reveals a diversity of protein bands. In general the number of components in a mixture is equal to the number of zones detected after electropohoresis. However, with a high molecular weight materials like proteins, more than one zone may arise from a single components.

Fig 3 Patterns of cowpea proteins of five varieties separated by polyacrylamide gel electrophoresis

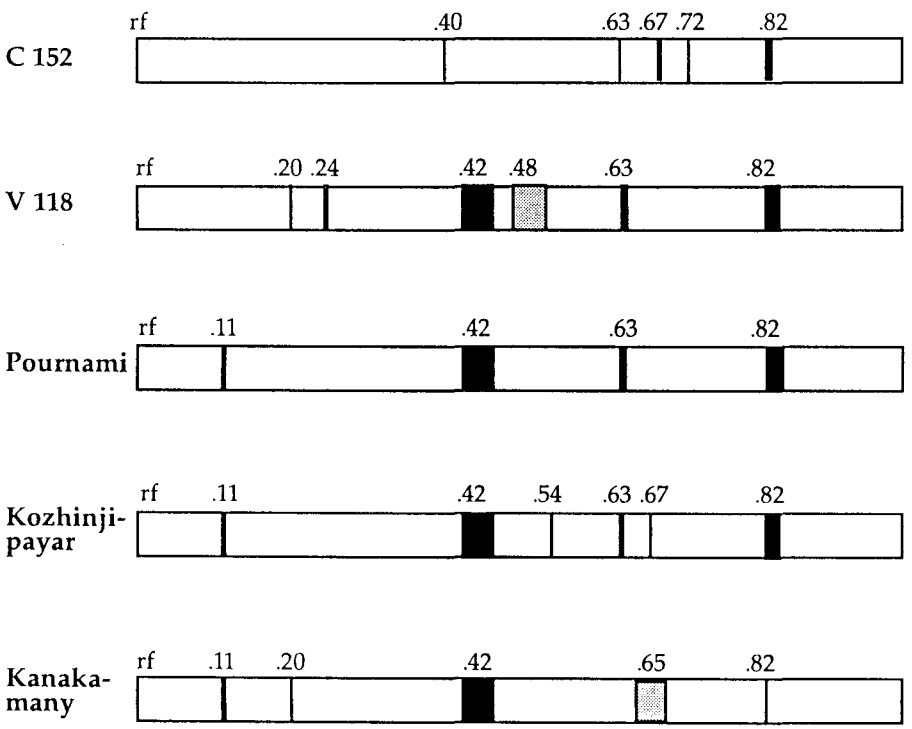
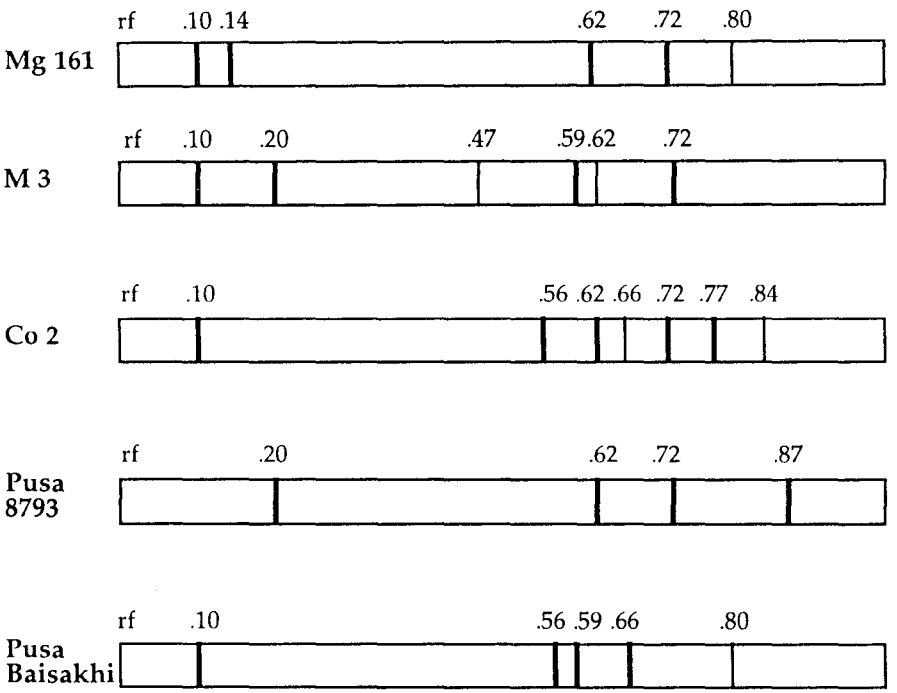


Fig 4 **Patterns of greengram proteins of five varieties separated by polyacrylamide gel electrophoresis**



The electrophoretic gels showing the pattern of protein extracted from cowpea and greengram varieties are presented in the fig 3 and 4. Ratio of the distance traveled by the fraction responsible for the coloured band to the distance of the solvent front is termed the rf value of that particular fraction.

The total number of protein fraction in cowpea variety, V188 and kozhinjipayar were 6 bands while in C 152, Pournami and Kanakamany only 5 bands were present. Among these only one band with an rf value of 0.43 was the most intense protein fraction in all the varieties while this major fraction was absent in C 152, where a trace band of 0.40 rf value was present.

In Pournami, Kozhinjipayar and Kanakamany fraction with 0.10, rf value was present which was not observed in C 152 and V 118. V118 and Kanakamany a trace band of 0.20 f value was also present in a lower concentration.

In one broad band with an rf value of 0.48 was present in V118 alone but the concentration of that fraction was very low as, revealed from the intensity of the colour. Protein fraction with an rf value of 0.63 was present in C152, V 118, Pournami and Kozhinjipayar. In Kanakamany another broad band of 0.65 rf value protein was present but the intensity was low. In C 152 and Kozhinjipayar, one trace band of 0,67 rf value protein fraction was also present.

Protein fraction of .82 of value was present in all the cowpea varieties studied. However concentration of this protein fraction was very low in Kanakamany.

In greengram varieties, 7 bands were present in the electrophoretic gel of Co 2 and 6 band in M 3. Only 5 bands were observed in other varieties viz; Mg 161, Pusa 8793 and Pusa Baisakhi. In greengram varieties all the bands were of less intensity when compared with that of cowpea varieties. In pusa 8793 one band with 0.03 rf value protein fraction was present which was absent in all other varieties. Protein fraction with an rf value of 0.10 was present in all the varieties except Pusa 8793. Protein fraction with an rf value of 0.14 was present in Mg 161 which was absent in all other greengram varieties. In M 3 and Pusa 8793

protein fraction of 0.20 rf value was present. Protein fraction of 0.47 rf value was present in M 3. In Co 2 and Pusa Baisakhi protein fraction of 0.56 rf value was present. Protein fraction of 0.59 rf value was present in M3 and Pusa Baisakhi. Another protein fraction with an rf value of 0.62 was present in all greengram varieties except Pusa Baisakhi. Protein fraction of 0.66 rf value was present in Co 2 and Pusa Baisakhi and that of 0.72 rf value was present in Mg 161, M 3, Co 2 and pusa 8793. These observations indicate the heterogenicity of the proteins of cowpea and greengram, irrespective of the varieties.

Biological utilization of nutritional quality of protein is influenced by various factors like amino acid composition, essential amino acid concentration, presence of limiting amino acid and antinutritional factors which interfere with the digestion and absorption of protein. Nutritional quality of pulse protein is judged generally by nitrogen balance, growth studies.

Pulses are said to be rich source of protein and protein quality of these food crops depends on the pattern of essential amino acids. Pulses are rich in lysine but they are generally poor in sulphur containing amino acids like methionine and cystine. Concentration of these amino acids in a pulse crop can also be a major determinant of its protein quality.

A standard procedure attempted to ascertain the quality of protein is assessment of its chemical score, which is computed on the basis of the extent to which its limiting amino acid deviates from that of standard reference egg protein. Since methionine is the most limiting amino acid, chemical score of different pulse varieties in the present experiment were calculated based on their methionine content.

Details pertaining to the amino acid content and chemical score of cowpea varieties (Table 13) revealed that cowpea varieties were poor in sulfur containing amino acids like methionine and cystine.

Table 13 Limiting amino acids and chemical obtained for cowpea varieties

No	Varieties	Methionine mg/g N	Cystine mg/g N	Chemical score
V_1	C 152	72.33	78.33	34.44
V_2	V 118	83.00	68.67	39.52
V_3	Pournami	77.33	71.67	36.82
V_4	Kozhinjipayar	88.33	81.33	42.06
V_5	Kanakamany	92.33	79.33	43.97
	F	104.837**	19.433**	104.812**
	SE	0.789	1.229	0.376
	CD	2.485	3.873	1.184

** significant at 5 per cent level

Methionine	V_5	V_4	V_3	V_2	V_1
Cystine	V_4	V_5	V_1	V_3	V_2
Chemical score	V_5	V_4	V_2	V_3	V_1

In these varieties methionine content ranged from 72.33 to 92. 33mg/g N. While in reference proteins methionine content was 210 mg/ g N. Among these varieties Kanakamany and maximum methionine content (92.33 mg/ g N). While C 152 had the minimum (72.33 mg/ g N). The difference in methionine content among all the five varieties studied were also found to be statistically significant.

Cystine content in cowpea varieties ranged from 68.67 mg/ g N in V 118 to 81.33 mg/ g N in kozhinjipayar, deviated widely from the cystine concentration in reference

protein (140 mg/ g N). Kanakamany (79.33 mg g N) and C 152 (78.33 mg/ g N) were on par with kozhinjipayar (81.33 mg/ g N) which obtained the highest value. Cystine content in these varieties were significantly higher than pournami (71.67 mg/ g N) and V118 (68.67 mg/g N). However, cystine content of pournami and V 118 were comparable. Bressani (1988) compared the amino acid pattern of cowpea with the FAO pattern and found that the most limiting amino acids were cystine and methionine. In an earlier study conducted by Phillips (1993) it has been reported that sulfur amino acid were lower in cowpea.

Chemical score of cowpea varieties were computed based on the first limiting amino acid methionine. As indicated in table 13 chemical score of cowpea varieties ranged from 34.44 to 43.97 per cent. Chemical score was highest in Kanakamany (43.97 per cent) followed by Kozhinjipayar (42.06 per cent). The lowest score was obtained for C 152 (34.44 per cent) followed by pournami (36.83 per cent). Difference in chemical score among cowpea varieties were also statistically significant. Varietal variation in chemical score was due to the significant difference in the methionine content of the varieties.

Cowpea varieties were ranked based on their limiting amino acid content and chemical score. As revealed in the ranking order cowpea variety, Kanakamany ranked first in methionine continue as well as in chemical score. It was followed by kozhinjipayar which was ranked first in the cystine content followed by Kanakamany. Variety V118 was ranked fourth in methionine content third in chemical score and lowest in cystine content. Pournami ranked third in methionine and fourth in cystine content and in chemical score. The assessment on these lines indicated the superiority of Kanakamany over other pulse varieties.

Amino acid composition and chemical score estimated on greengram varieties revealed that Methionine content ranged from 49.33 to 75.67 mg/ g N. Methionine content was highest in Mg 161 (75.67 mg/g N) followed by pournami (67.67 mg/g N) and the difference between the two varieties was also statistically significant. Methionine content was lowest in Pusa 8793 (49.33 mg/ g N) followed by M3 (52.33 mg/ g N). Methionine content of M3 was comparable with Pusa Baisakhi and Pusa 8793.

Table 14 Limiting amino acids and chemical scores obtained for greengram varieties

No	Varieties	Methionine mg/g N	Cystine mg/g N	Chemical score Methionine
V_1	Mg 161	75.67	58.33	36.03
V_2	M 3	52.33	43.33	24.92
V_3	Co 2	67.67	52.00	32.22
V_4	Pusa 8793	49.33	55.33	23.49
V_5	Pusa Baisakhi	56.67	47.33	26.98
	F	63.751**	28.206*	63.623**
	SE	01.382	01.130	00.659
	CD	04.356	03.577	02.076

*** Significant at 1 per cent level**

**** Significant at 5 per cent level**

Methionine	V_1	V_3	V_5	V_2	V_4
Cystine	V_1	V_4	V_3	V_5	V_2
Chemical score	V_1	V_3	V_5	V_2	V_4

Cystine content in greengram varieties ranged from 43.33 mg/g N in M3 to 58.33 mg/ N in Mg 161. Cystine content was highest in Mg 161 (58.33 mg/ g N) followed by pusa 8793 (55.33 mg/ g N) while cystine content of pusa 8793 was comparable with that of v Mg 161 and Co 2. Cystine content was lowest in M3 (43.33 mg/g N) followed by Pusa Baisakhi (47.33 mg/ g N). Difference between these two varieties were also observed to be statistically significant.

Chemical score of green gram varieties ranged from 23.49 per cent in pusa 8793 to 36.03 per cent in mg 161. Chemical score was highest in Mg 161 (36.03 per cent) followed by Co 2 (32.22 per cent). Chemical score of these 2 varieties showed significant variation and were significantly higher than other varieties. Chemical score was lowest in pusa 8793 (23.44 mg/ g N) followed by M3 (24.92 mg/ g N) and were comparable. M3 was comparable with Pusa Baisakhi in chemical score.

Greengram varieties were ranked according to methionine and cystine content and chemical score. As indicated in the ranking order Mg 161 was ranked first in methionine, Cystine and chemical score. Co 3 ranked second in methionine and chemical score and third in cystine. Pusa 8793 was ranked first in cystine content but was the last with respect to methionine content and chemical score. Pusa Baisakhi ranked third in Methionine content and chemical score and secured 4th rank in cystine content. The variety M 3 ranked fourth in methionine content and chemical score and fifth in cystine content.

Assessment of protein quality of different pulse varieties based on limiting amino acid and chemical score revealed that among cowpea varieties Kanakamany was superior and in greengram varieties Kanakamany was superior and in greengram varieties Mg 161 was superior. Amino acid content of grain legumes depends on species, varieties, locality and management practices like irrigation and fertilization. Zinc and sulfur fertilizers increase Methionine content. Significant variation in methionine and Cystine content in pulses was reported by Salunkhe et al (1985) and Chavan et al. (1994). Since the limiting amino acid content and chemical score of cowpea and greengram varieties varied significantly these parameters alone cannot be taken in to consideration to determine the protein quality.

Quality of protein is to be assessed by biological experiments which assess the digestion and utilization of proteins. Thus biological methods based on growth and nitrogen retention were resorted for determining the overall quality of the protein of different varieties of pulses. The biological parameters studied were Protein Efficiency Ratio (PER) and Feed Efficiency Ratio (FER) which denote the growth of the animals based on the protein and food intake respectively. Net Protein Utilization (NPU) which takes into account both absorption and retention of protein in the living body and Biological Value (BV) of protein which considers only protein retention in similar situations were also studied.

Salient findings of the animal experiments of 28 days duration and 14 days were the basis to work out the indices like PER, FER, BV, Digestibility Coefficient (DC), NPU and Utilisable Protein (UP) for all the varieties of cowpea and greengram. PER and FER were calculated from the growth of the animal and its protein and food intake. UP was calculated as the product of protein content and the net protein utilization.

The PER of cowpea varieties ranged from 1.62 to 1.92 per cent. Among different cowpea varieties pournami obtained the highest PER (1.92 per cent) which was significantly higher than other varieties and the lowest PER was recorded for C 152 (1.62 per cent). No significant variation was observed among the other 3 varieties.

FER of pournami (.19 per cent) and Kanakamany (0.19 per cent) were significantly higher than other varieties, which obtained a PER of 0.15 per cent.

Digestibility Coefficient of cowpea varieties ranged from 79.75 to 90.88 per cent. As revealed in the table there was significant varietal variations among different cowpea varieties. Digestibility coefficient was highest in V 118 (90.88 per cent) followed by Kanakamany (86.24 per cent) and the value was lowest in Kozhinjipayar (79.75 per cent)

Significant varietal variation was also observed in the biological value of cowpea varieties. Biological value ranged from 88.15 to 96.44 per cent. BV was highest in V118 (96.44 per cent) and was comparable wit that of C 152 (95.41 per cent) and Kozhinjipayar (94.79 per cent). BV of Kanakamany was significantly lower than other varieties. Methionine

Table 15 Protein quality parameters of cowpea varieties

	Varieties	Protein Efficiency Ratio	Feed Efficiency Ratio	Biological Value	Digesti-bility Coefficient	Net Protein Utilisation	Utilisable Protein
V_1	C 152	01.62	00.15	95.41	82.66	78.86	17.97
V_2	V 118	01.71	00.15	96.44	90.88	86.13	18.82
V_3	Pournami	01.92	00.19	93.89	85.00	79.81	18.68
V_4	Kozhinji-payar	01.75	00.15	94.79	79.75	75.60	15.82
V_5	Kanaka-many	01.71	00.19	88.15	86.24	76.02	18.29
	F	04.679**	13.551**	16.961**	204.108**	137.356**	233.493**
	SE	00.050	00.005	00.791	000.291	000.361	000.081
	CD	00.146	00.015	02.493	000.917	001.137	000.257

**** Significant at 5 per cent level**

Protein Efficiency Ratio	V_3	V_4	V_5	V_2	V_1
Feed Efficiency Ratio	V_3	V_5	V_2	V_4	V_1
Biological Value	V_2	V_1	V_4	V_3	V_5
Digestibility Coefficient	V_2	V_5	V_3	V_1	V_4
Net Protein Utilisation	V_2	V_3	V_1	V_5	V_4
Utilisable Protein	V_2	V_3	V_5	V_1	V_4

is found to have an influence on BV because of its tardiness to enter the metabolic pool ever when other amino acids are available in good supply. NPU ranged from 75.60 to 86.13 per cent. The highest NPU was obtained for V 118 (86.13 per cent) which was significantly higher than other varieties. NPU was lowest for kozhinjipayar (75.60 per cent) and was on par with Kanakamany (76.02 per cent).

UP was highest in V118 (18.82 per cent) followed by pournami (18.68 per cent) and the values were comparable. There was significant variation between the other three varieties and the lowest utilisable protein was obtained for Kozhinjipayar (15.82 per cent).

Assessment of the protein quality characteristics revealed that among cowpea varieties, V118 was superior as for as protein quality characteristics were concerned except for PER and FER. Pournami variety was superior in its PER and FER. In a similar study conducted earlier the total digestibility and NPU of different varieties of cowpea were found to vary from 87-92 (Khan *et al* 1979).

A wide range of variation for protein quality parameters in pulses has been reported by many workers. Sgarbieri (1989); Sotelo and Hernendez (1980) and Tezoto and Sgarbieri (1990) have studied PER; while Sharma *et al* (1991); Sood *et al* (1991); and Umaid Singh *et al* (1993) had concentrated their studies on the BV of different pulses. Varietal differences seemed to have no effect on the PER and FER values in vegetable pea flour as reported by Kamlesh and Neelam (1993).

Cowpea varieties are ranked according to their protein quality characteristics. As revealed from the ranking order, pournami ranked first in PER and FER and second in NPU and UP. Pournami ranked third in DC and fourth in BV, V118 ranked first in the BV, DC,UP and NPU and ranked third in FER and fourth in PER. Even though Kanakamany ranked first in protein and methionine content it ranked second for FER and DC and third for PER. However, the same variety ranked lower in NPU and registered the lowest BV. Protein quality indices of green gram varieties revealed that there was significnat varietal variation. PER ranged from 2.64 to 2.83 per cent. Among greengram varieties Mg 161 obtained a significantly higher PER (02.83 per cent) followed by Co 2 (02.80 per cent). PER was

lowest for Pusa 8793 (02.64 per cent). Difference in PER among varieties were statistically significant.

FER ranged from 0.21 to 0.25. FER was highest in Mg 161 (0.25) and was lowest in Pusa Baisakhi and was significantly lower. FER of Mg 161 (0.25) was on par with pusa 8793 (0.24) and differences in FER between other three varieties were comparable.

DC ranged from 75.44 in Co 2 to 89.48 in Pusa Baisakhi. DC of Pusa Baisakhi (89.48) and Mg 161 (88.49) were comparable. Lowest value obtained for Co 2 (75.44) was comparable with Pusa 8793 (75.55).

BV (132) of greengram varieties ranged from 84.87 to 94.18. BV was highest for Pusa Baisakhi (94.18) and was on par with pusa 8793 (93.22). BV of other two varieties were comparable. Since the DC and BV were highest for Pusa Baisakhi, NPU was also highest for this variety. NPU ranged from 65.48 to 84.27 and was lowest for Co 2 (65.48). Results in the Table revealed that differences in NPU among greengram varieties was statistically significant.

Significant varietal variation was also observed in UP content. It ranged from 12.74 to 16.76. The highest UP content was obtained for Mg 161 (16.76) followed by Pusa Baisakhi (16.05) and the lowest was observed in Co 2 (12.74). Greengram varieties were ranked based on their protein quality characteristics. As indicated from the ranking order greengram varieties, Mg 161 and Pusa Baisakhi and Mg 161 were found to be superior in protein quality as they obtained higher values for the protein quality indices. Growth promoting factors PER and FER and UP were better in Mg 161 where as Pusa Baisakhi was superior with respect to the Nitrogen balance studies BV, DC and NPU. Perusal of the results of protein quality indicators revealed that protein content and quality were not correlated.

Protein content of cowpea was positively correlated with grain weight (0.6566**) and volume (.6144*) where as similar association was not observed in greengram.

Among the various amino acids studied lysine and arginine content were found to be positively associated with protein content (.5800* and .8097** respectively). Where as the

Table 16 Protein quality parameters of greengram varieties

No	Varieties	Protein Efficiency Ratio	Feed Efficiency Ratio	Biological Value	Digesti-bility Coefficient	Net Protein Utilisation	Utilisable Protein
V_1	Mg 161	02.83	00.25	86.63	88.49	76.66	16.76
V_2	M3	02.75	00.23	84.87	87.57	74.32	14.99
V_3	Co 2	02.81	00.23	86.79	75.44	65.48	12.74
V_4	Pusa 8793	02.64	00.24	93.22	75.55	70.42	15.58
V_5	Pusa baisakhi	02.65	00.21	94.18	89.48	84.27	16.05
	F	02.279	09.549**	167.156**	382.611**	184.063**	204.526**
	SE	00.059	00.005	000.328	000.366	000.518	000.107
	CD	—	00.015	001.035	001.154	001.633	000.377

**** Significant at 5 per cent level**

Protein Efficiency Ratio	V_1	V_3	V_2	V_5	V_4
Feed Efficiency Ratio	V_1	V_4	V_3	V_2	V_5
Biological Value	V_5	V_4	V_3	V_1	V_2
Digestibility Coefficient	V_5	V_1	V_2	V_4	V_3
Net Protein Utilisation	V_5	V_1	V_2	V_4	V_3
Utilisable Protein	V_1	V_5	V_4	V_2	V_3

association of lysine and protein was negative (-.8087**) in greengram and positive for cystine and protein (.6147*) in greengram.

NPU of cowpea was associated with DC (.8043**) and BV (.5672*) and negatively associated with tannin (-.8468**) and phytin content (-.8304**). UP was also positively correlated with DC (.8227**), NPU (.6390*) and protein content (.5904*) where as the association of UP was negative with phytin (-.7055**). FER was also directly associated with protein content (.6216*).

In greengram NPU was positively correlated with DC (.8602**) and negatively associated with tannin content (-6033**). UP was also correlated with NPU (.7545**) and DC (.6582**) and negatively associated with tannin (-.5721**). FER was correlated with the protein content.

Nitrogen content may not be an accurate estimate of true protein, as different strains may contain different quantities of non protein nitrogen (NPN). The NPN may contain peptides and amino acids that are nutritionally equivalent of protein, as well as other nitrogen containing compounds that cannot be utilized by monogastric animals.

Protein digestibility varied widely among varieties. It is difficult to explain the high variability of BV in varieties of the same species because of the involvement of many factors. In the present study, it is depicted in Kanakamany which got a lower BV with a higher protein and methionine contents.

Metroglyph and index score method

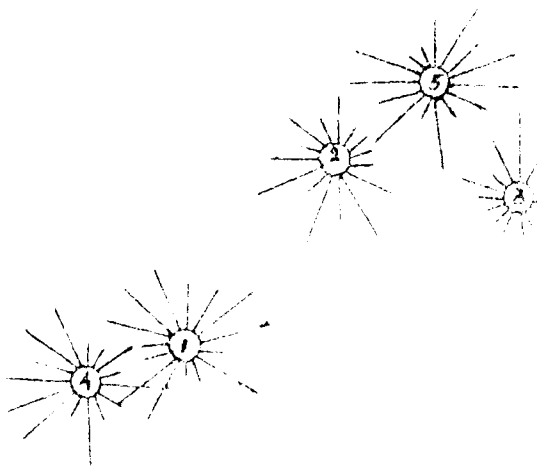
Metroglyph and index score method was administered to study the total variation of various qualities in pulse varieties (Fig 5 and 6). Varieties were analyzed in triplicate for volume expansion, protein, calcium, iron, methionine, Cystine chemical score, cooking time, leaching loss, tannin, phytin trypsin inhibitor raffinose, stachyose and verbascose and the mean values of each parameter were worked out. AMong the parameters, two most variable characters, viz, stachyose and verbascose were selected. Stachyose was used on the X axis and verbascose on the Y axis. The means of Y values are plotted against the mean

Table 17 Mean values for different parameters of cowpea varieties

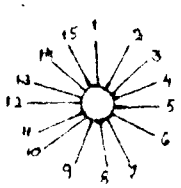
Parameters	C 152	V 118	Pournami	Kozhinji-payar	Kanaka-many
Volume expansion	105.00(2)	108.00(2)	118.00(3)	98.92(1)	105.00(2)
Protein	22.78(2)	21.85(1)	23.41(3)	20.92(1)	24.06(3)
Calcium	238.00(3)	214.00(1)	224.00(2)	226.00(2)	224.00(2)
Iron	10.40(3)	07.20(1)	07.90(1)	06.80(1)	12.30(3)
Cooking time	74.17(1)	69.33(1)	68.23(1)	52.00(3)	47.00(3)
Leaching loss	36.67(3)	43.00(2)	49.00(1)	49.00(1)	38.33(2)
Tannin	522.00(1)	180.00(3)	237.00(3)	520.00(1)	538.00(1)
Methionine	72.33(1)	83.00(2)	77.33(1)	88.33(3)	92.33(3)
Phytin	366.00(3)	328.00(3)	389.00(1)	423.00(1)	387.00(1)
Cystine	78.33(3)	68.67(1)	71.67(1)	81.33(3)	79.33(3)
Trypsin-inhibitor	44.18(1)	29.26(3)	40.36(1)	36.49(3)	38.48(2)
Chemical score	34.44(1)	39.52(2)	36.83(1)	42.06(3)	43.97(3)
Raffinose	00.42(3)	00.67(1)	00.51(2)	00.46(3)	00.48(3)
Stachyose	02.26(3)	02.63(2)	03.16(1)	02.00(3)	02.90(1)
Verbascose	03.10(3)	03.60(1)	03.50(2)	03.00(3)	03.80(1)
Total	33	26	24	32	33
Ranking	R_1	R_4	R_5	R_3	R_1

Figures in parenthesis indicate scores

Fig 5 Metroglyph indicating the quality of cowpea varieties



1 C 152
2 V 118
3 Pournami
4 Kozhinjipayar
5 Kanakamany



1 Volume expansion
2 Protein
3 Calcium
4 Iron
5 Cooking time
6 Leaching loss
7 Tannin
8 Methionine
9 Phytine
10 Cystine
11 Trypsin inhibitor
12 Chemical score
13 Raffinose
14 Stachyose
15 Verbascose

Verbascose

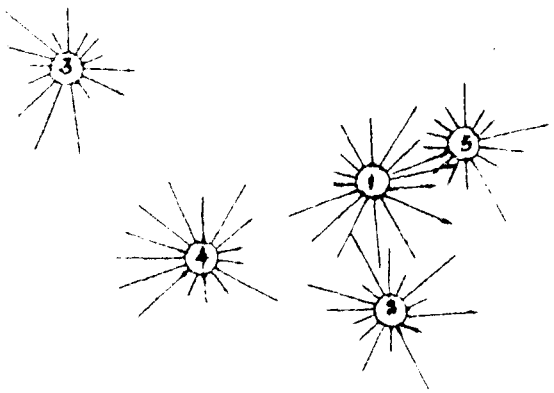
Stachyose

Table 18 Mean values for different parameters of greengram varieties

Parameters	Mg 161	M3	Co_2	Pusa 8793	Pusa-Baisakhi
Volume expansion	130.00(2)	130.00(2)	133.00(2)	113.00(2)	115.00(2)
Protein	21.86(3)	20.17(1)	19.46(1)	22.13(3)	19.05(1)
Calcium	261.00(2)	277.00(3)	248.00(1)	262.00(2)	250.00(1)
Iron	12.60(3)	05.30(1)	08.10(1)	08.50(1)	12.30(3)
Cooking time	34.18(2)	31.33(3)	33.11(2)	40.33(1)	32.41(2)
Leaching loss	32.33(3)	55.67(1)	51.67(2)	41.67(3)	63.67(1)
Tannin	317.00(3)	310.00(3)	400.00(1)	390.00(1)	340.00(3)
Methionine	75.67(3)	52.33(1)	67.67(3)	49.33(1)	56.67(1)
Phytin	209.00(3)	230.00(2)	201.67(3)	265.00(1)	254.00(1)
Cystine	58.33(3)	43.33(1)	52.67(2)	55.33(3)	47.33(1)
Trypsin inhibitor	36.03(3)	24.92(1)	32.22(3)	23.49(1)	26.98(1)
Chemical score	36.03(1)	24.92(2)	32.22(1)	23.49(3)	26.98(1)
Raffinose	00.71(1)	00.58(3)	00.61(2)	00.41(3)	00.63(1)
Stachyose	01.76(1)	01.80(1)	00.95(3)	01.30(3)	02.03(1)
Verbascose	03.46(2)	03.10(3)	03.76(1)	03.28(3)	03.56(1)
Total	37	27	26	31	23
Ranking	R_1	R_3	R_4	R_2	R_5

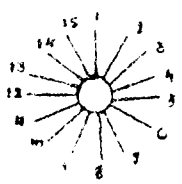
Figures in parenthesis indicate scores

Fig 6 Metroglyph indicating the quality of greengram varieties



1 Mg 161
2 M_3
3 Co_2
4 Pusa 8793
5 Pusa baisakhi

Verbascose



1 Volume expansion
2 Protein
3 Calcium
4 Iron
5 Cooking time
6 Leaching loss
7 Tannin
8 Methionine
9 Phytine
10 Cystine
11 Trypsin inhibitor
12 Chemical score
13 Raffinose
14 Stachyose
15 Verbascose

Stachyose

of X value foe each variety and thus each variety is represented by a glyph on the graph. Including stachyose and verbascose all quality parameters are represented by rays on the glyph, the rays for the same character having the same position on each glyph.

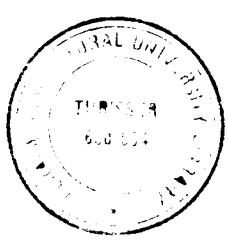
Range of variation in quality parameter is represented by different length of rays, ie a variety having low value for a particular quality parameter will have a smaller ray while another variety with higher values will have longer rays. Thus the length of the ray for all the varieties will be either short, medium or long depending on the value.

The index values were decided on the basis of range of variability. The range of variability with regard to each quality parameter was classified into three groups and the details are represented in Tables 17 and 18. The sum of index values with regard to all the quality parameter of a variety is the indication of the overall quality of that particular variety.

Among the qualities studied, higher values for parameters, like volume expansion, protein, calcium, iron, Methionine cystine and chemical score indicates better or superior quality, hence score, one was given for lower means and 3 for higher means. Where as cooking time, leaching loss and antinutritional factors are parameters where higher values indicated poor quality for the variety, hence score 3 was given for lower means and 1 for higher means. Mean value and score for each parameter is given in Tables 17 and 18. In the glyph length of the rays are proportional to the scores.

In the glyph representation varieties with longer rays are of better quality. Among the varieties, the highest total score of 33 was obtained for Kanakamany and C 152, followed by Kozhinjipayar (32), V 118 (26) and Pournami (24).

Among greengram varieties Mg 161 obtained the maximum score of 37 followed by Pusa 8793 (31), M_3 (27), Co_2 (26) and Pusa Baisakhi (23).



4.6 Cholesterol lowering effect of cowpea (Table 19 - 21)

Pulses are known to exert hypocholesterolemic effect (Soni *et al* 1982). Hence apart from serving as an important protein source, regular consumption of pulses may account for the lower incidence of ischaemic heart disease.

Animal proteins are generally believed to be hypercholesterolemic while plant proteins show lipid lowering effect (Carroll, 1978, Kuyvenhoven *et al.*, 1986). A significant decrease in serum cholesterol in man has been reported, when a diet high in animal protein was changed to a diet containing 25g of proteins derived from legumes and cereals. Several studies in animal and man, have shown whole legumes to be effective cholesterol lowering agents when consumed on a habitual basis, even with a background diet high in fat and cholesterol.

However, considerable variation among species in their response to both the quantity and the composition of the protein in the diet have been observed by Susan *et al.* 1987). It was also reported that the quantity and quality of dietary proteins are reported to be important nutritional factors in the determination of risk from ischaemic heart disease. Dietary protein is also reported to influence the serum cholesterol level in animals by moderating cholesterol dynamics (Huff and Carroll 1980).

The protein effect on cholesterol metabolism appear to be dependent on dietary cholesterol (Nagata *et al.*, 1980; 1981 and Eklund and Sjoblom, 1980). The cholesterol effect of any protein is particularly related to its amino acid composition and that the balance of essential and non essential amino acid is important in determining the response (Huff and Carroll, 1980).

A number of studies have shown substantial reduction in plasma cholesterol level of hyperlipidemic human subjects consuming variety of dried (boiled a Canned) legumes on a regular basic (Bingiven *et al* 1981; Jankins *et al* 1983; Andercon *et al* 1984). Winje *et al* (1984) reported that lysine was required to maintain normal level of fat in the liver in rates fed died containing amino acid mixture. Lysine supplementation of lysine deficient diet

Table 19 Lysine:Arginine ratio of cowpea varieties

No	Varieties	Lysine mg/g N	Agrinine mg/g N ratio	Lysine Arginine
V_1	C 152	428.33	401.00	01.07
V_2	V 118	424.33	403.33	01.05
V_3	Pournami	430.00	417.67	01.03
V_4	Kozhinjipayar	421.67	397.67	01.06
V_5	Kanakamany	425.67	420.67	01.01
	F	009.866**	061.339**	21.101**
	SE	001.045	001.326	00.005
	CD	003.292	004.178	00.017

** Significant at 5 per cent level

Lysine	V_3	V_1	V_5	V_2	V_4
Arginine	V_5	V_3	V_2	V_1	V_4
Lysine: Arginine ratio	V_5	V_3	V_2	V_4	V_1

find out the lysine:arginine ratio of cowpea and greengram varieties studied lysine and arginine content of ten pulse varieties were estimated and the results are presented in the Tables 19 and 20.

Arginine and lysine content of different varieties of cowpea and greengram were estimated and as indicated in the Tables 19 and 20 lysine content of cowpea varieties ranged from 421.67 mg/g N in Kozhinjipayar to 430.00 mg/ g N in pournami. Lysine content was highest in Pournami (430.00 mg/g N) followed by C 152 (428.33 mg/ g N) and these varieties were comparable. Lysine content was lowest in Kozhinjipayar (421.67 mg/g N) while V 118, with 424.33 mg/ g N, was comparable with the former. Lysine content of Kanakamany (425.67 mg/ g N) was on par with that of C 152 and V 118.

In greengram lysine content was found to vary from 463.67 to 501.67 mg/g N. The maximum lysine was obtained for Pusa Baisakhi (501.67 mg/g N) followed by M3 (491.67 mg/g N) which were significantly higher than other varieties. THe lysine content was minimum in Pusa 8793 (463.67 mg/g N) and was significantly lower than other varieties. Among different varieties lysine in Co 2 (481 mg/g N) and Mg 161 (477.67 mg/ g N) were comparable.

Arginine content of cowpea varieties ranged from 397.67 mg/g N in Kozhinjipayar to 420.67 mg/g N in Kanakamany. Arginine content in Kanakamany (420.67 mg/g N) was on par with pournami (417.67 mg/g N) and significantly higher than other varieties. The lowest arginine content was observed in Kozhinjipayar (397.67 mg/ g N) and C 152 (401.00 mg/g N).

As evident from Table 20, there was significant varietal varietal variation in arginine content among different varieties. Arginine content in green gram varieties ranged from 410.33 mg/g N in Co 2 to 492.00 mg/ g N in Mg 161. Arginine content was maximum in Mg 161 (492.00 mg/g N) followed by M3 (473.67 mg/ g N) and Pusa Baisakhi (466.67 mg/ g N).

Lysine Arginine ratio ranged from 1.01 to 1.07 in cowpea varieties. Lysine arginine ratio was highest in C 152 (1.07) and was on par with Kozhinjipayar (1.06). The ratio of

Table 20 Lysine:Arginine ratio of greengram varieties

No	Varieties	Lysine mg/g N	Agrinine mg/g N	Lysine Arginine ratio
V_1	Mg 161	477.67	492.00	00.97
V_2	M 3	491.67	473.67	01.04
V_3	Co 2	481.00	410.33	01.17
V_4	Pusa 8793	463.67	428.33	01.08
V_5	Pusa Baisakhi	501.67	466.67	01.07
	F	145.556**	602.192**	247.221**
	SE	001.194	001.375	000.005
	CD	003.761	004.334	000.015

** Significant at 5 per cent level

Lysine	V_5	V_2	V_3	V_1	V_4
Arginine	V_1	V_2	V_5	V_4	V_3
Lysine: Arginine ratio	V_1	V_2	V_5	V_4	V_3

Kritchevsky (1979) has suggested that the dietary ratio of arginine:lysine is important in the development of atherosclerosis. The relative abundance of lysine in animal proteins is postulated to inhibit liver arginine activity (Cittadini *et al*, 1964) and thus increase the availability of arginine for incorporation into the arginine rich apoprotein of LDL. Alternatively Gibeny (1982) has suggested a hormone mediated effect involving insulin and glucagon. Insulin is known to be correlated positively and glucagon is correlated negatively with the diurnal variation in the activity of rat hepatic hydroxymethylglutaryl Co A reductase which is the rate limiting enzyme in cholesterol synthesis, Nepokroeff et al 1973. Gibney (1982) has proposed that the release of arginine following soya proteins digestion leads to an enhanced stimulations of insulin release which is turn stimulates HMG Co A reductase and increases the turnover of very low density lipoprotein (VLDL). Some observations with soya protein are consisted with the observations of Jenkins *et al*. (1980) who noted reduced insulin peaks following meals of legumes. Noseda *et al* (1980) discovered that patients consuming a soya protein diet showed an increased release of glucagon following infusion of arginine into the blood stream. They suggest that increased release of glucagon which has been reported to interfere with hepatic cholesterol synthesis, may be responsible for the observed cholesterol lowering ability of soyabean proteins.

Effect of alteration of lysine:arginine ratio on cholesterol metabolism has been investigated in detail by Raj Mohan (1989) and found that there is an optimum ratio of one as far as hypocholesterolemic effect of protein is concerned. Hence, in the present study Kanakamany variety of cowpea with optimum Lysine:arginine ratio (1.01) was tested for its hypocholesterolemic effect in the animal experiment of 100 days duration. Animals were divided into three groups, one fed with normal diet (G 1), another one high fat high cholesterol diet (G2) and third one on high fat high cholesterol diet with Kanakamany (G3). The diets were given at 16 per cent protein level. Casein was given as the source of protein for G1 and G2 and Kanakamany at 16 per cent protein protein level was fed to G3.

Initial body weight of the animals were recorded at the starting of the experiment. Increase in body weight was recorded every weak and at the end of the experiment.

The rats were stunned and killed by decapitation. Liver and blood were collected for the lipid estimation. Liver weight was also recorded. Weight gain, liver weight, liver and serum cholesterol and triglyceride and faecal sterols were determined and the results are presented in Table 21.

As indicated in Table 21, weight gain was highest in normal diet (140 g) and was on par with high fat high cholesterol diet (137.20g). Body weight gain of animal fed cholesterol diet significantly lower (66.30 g). Kanwall *et al* (1987) also observed a significantly lower body weight gain for rats fed with gram diet. George *et al* (1995) also reported growth reducing effect of dietary legumes, but the growth rates were close to that of control after 200 days. Slow rate of growth in the first 200 days may due to adaptation to the diet. Variation in liver weight was also observed among the three groups. Liver weight was highest for the rats fed with high fat high cholesterol diet (14.41 g) followed by G3 fed with high fat high cholesterol pulse diet (9.99 g). Liver weight was lowest for rats fed with normal diet. The liver weight of rats of G2 were significantly higher than the liver weights of rats of G3 and G1. This fat and cholesterol feeding increased the liver weight but this increase was significantly lower in G3 where cholesterol was fed along with Kanakamany. Thus it is evident that Kanakamany is useful in protecting the liver from becoming fatty under high fat high cholesterol dietary conditions. Kanwall *et al.* (1987) also reported significantly lower liver weight in rats fed diet containing different gram varieties.

Epidemiological investigations indicate that the intake of total fat is positively correlated with serum cholesterol concentration. Serum cholesterol levels are a strong risk factor for ischaemic heart disease. Hence in the present student liver and serum cholesterol and triglyceride were estimated to evaluate the hypocholesterolemic effect of Cowpea.

Cholesterol is a fat like steroid alcohol found in blood and tissue. It occurs in atheroma of the arteries. Most of the body's cholesterol is synthesized in the liver bit some are absorbed from the diet. Triglyceride is a compound consisting of 3 molecules of fatty acids esterified to glycerol. It is a neutral fat synthesized for storage in animal adipose cells. On enzymatic hydrolysis it releases free fatty acids in the blood.

Table 21 Effect of Kanakamany on the lipid profile of experimental animals

Groups	Body weight gain (g)	Liver weight (g)	Cholesterol Liver mg/g	Cholesterol Serum mg/100ml	Triglyceride Liver mg/g	Triglyceride Serum mg/100ml	Faecal Sterol mg/rat/day
Group 1 Normal diet(G1)	140.00	07.24	02.70	55.20	07.52	04.91	20.10
Group 2 High fat high cholesterol diet (G2)	137.20	14.41	08.10	130.00	08.94	07.59	47.10
Group 3 High fat high cholesterol diet with Kanakamany (G3)	66.30	09.99	07.55	63.00	07.87	05.91	33.40
F	66.23**	32.06**	149.26**	157.12**	01.46**	16.58**	47.86**
SE	05.13	00.639	00.243	03.279	00.613	00.331	01.951
CD	17.949	02.233	00.850	11.468	—01.159	06.825	

** Significant a 5 per cent level

Results of the animal experiment revealed that there was significant difference in the cholesterol levels among the three groups. Liver cholesterol level was highest in group 2 (8.10 mg/g) and was on par with that of G 3 (7.55 mg/g). Liver cholesterol content was lowest in normal diet. Even though incorporation of pulses in the high fat high cholesterol diet decreased the liver cholesterol content, the difference between G2 and G3 were not significant.

Serum cholesterol level was also highest in G 2 (130 mg/ 100 ml) and was significantly lower in G 3 (63 mg/100 ml) in which rats were fed with high fat high cholesterol diet and Kanakamany. Serum cholesterol level in animals fed with normal diet was lowest (55.25 mg/100 ml) but was on par with the experimental diet (G 3.)

According to Margaret and Howard (1994) total cholesterol is a statistically significant diet specific responsive lipid. Results in the Table 21 indicate difference in the liver triglyceride content among the three groups. Liver triglyceride was highest in high fat high cholesterol diet (8.94 mg/g) followed by high fat high cholesterol + pulse diet G3 (7.87 mg/g). Triglyceride content was lowest in normal diet (7.52 mg/g). Serum triglyceride content was also highest in animals fed with high fat high cholesterol diet (7.59 mg/100 ml) followed by high fat high cholesterol diet with Kanakamany (5.91 mg/100 ml). Animals fed normal diet obtained the lowest triglycerides.

Faecal sterol content varied and was highest for animals fed with high fat high cholesterol diet (47.10 mg/rat/day) followed by high fat high cholesterol diet with Kanakamany (33.40 mg/rat/day) and normal diet (20.10 mg/ rat/ day). The difference in faecal sterol content among the three diets were statistically significant.

According to Susan *et al.* (1993) plasma lipid levels were found to be unrelated to the excretion of steroids in the faeces. Liver and serum lipid profile were highest for high fat high cholesterol diet. Incorporation of pulses in high fat high cholesterol diet decreased the lipid level in liver and serum, even though it was higher than that of normal diet. Faecal sterol content was also lower in the high fat high cholesterol diet with Kanakamany when compared with high fat high cholesterol diet with out it. This variation indicated increased

absorption of lipid from the intestine. Decrease in liver and serum lipid content of rats fed with high fat high cholesterol diet with Kanakamany may be due to the increased hepatic degradation of cholesterol.

The decrease in the concentration of cholesterol in liver in rats fed with Kanakamany may be due to the enhanced rate of cholesterol degradation when compared to its synthesis. Decrease in serum triglyceride may be due to the increased uptake of triglyceride rich lipoprotein from the circulation due to the increased activity of lipoprotein lipase.

The increase in the faecal excretion of sterols correlates well with the hypocholesterolemic effect of Kanakamany. The only way by which the cholesterol can leave the body is via the hepatobiliary three as sterol itself and its major degradation products, the bile acids. The faecal excretion of neutral sterol is positively correlated with the hypocholesterolemic effect.

Results of the present study indicated the effective cholesterol lowering action of Kanakamany. This effect may be due to a number of factors working together. The contributing factors are low fat content (Snook *et al.*, 1985 and Weisweiler *et al.*, 1986) lower cholesterol : saturated fat index (Connor *et al.*, 1986) highly unsaturated fat containing linoleic and linolenic acid (Mahadevappa and Rama, 1983) and due to the presence of sistosterol and camposterol which reduces the absorption of cholesterol (Salen *et al.* 1970). Previous workers have suggested that the dietary fiber of legumes is the component most likely to affect plasma lipids (Susan *et al.*, 1989). The effect was attributed tot he inhibition of hepatic cholesterol synthesis (Anderson *et al.*, 1984). Legumes contain few mono and disaccharides which decrease triglyceride level (Anderson *et al.*, 1984). The effect of pulse protein on lipid lowering effect may also depend on its amino acid composition (Kritchevsky *et al.*, 1982). Many of the amino acids excert significant effect on lipid metabolism (Rajmohan, 1989). According to Muraleedhara Kurup (1984) adequate level of lysine in the diet corrects the impaired lipid metabolism observed in lysine deficient to the normal level, but further administration of lysine above the normal requirement does not affect lipid metabolism in rats fed cholesterol free diet. On the other hand increased concentrations of cholesterol and

triglyceride in the serum and aorta were observed in rats fed excess methionine (Muraleedhara Kurup, 1984). Ayoma *et al.*, (1973) found that reduction of sulphur containing amino acid resulted in a marked decrease in liver lipids in rats. Lysine and methionine which appear to have opposite effect on lipid metabolism, in the liver, is an important justification for the hypocholesterolemic effect of Kanakamany. Pulses in general are rich in lysine and deficient in methionine.

Rats fed with high fat high cholesterol diet containing blackgram showed significantly lower lipid levels in serum, liver and aorta when compared to casein replacing blackgram under similar condition (Muraleedhara Kurup 1984). While studying the effect of dietary pulse protein in atherosclerosis it was observed that not all pulse proteins have cholesterol lowering action. Bengalgram and greengram were also found to be without effects while blackgram and horsegram were found to lower cholesterol levels (Saraswathy 1970).

4.7 Influence of processing on the qualities of Cowpea variety Kanakamany and Green gram variety Mg 161 (Tables 22 to 28)

Processing is a pre condition for the consumption of all foods including legumes. Traditionally pulses are consumed after processing into various products or consumed as whole grain treated through moist heat, dry heat, germination and fermentation.

Influence of processing and cooking on the cooking qualities, nutritional composition and antinutritional factors in cowpea and greengram were studied. Different processing and cooking methods studied were boiling (T_2), soaking and boiling (T_3), steaming (T_4), pressure cooking (T_5), soaking and steaming (T_6), germination (T_7) and germination and steaming (T_8).

From among the five varieties of cowpea and greengram studied one variety each of cowpea (Kanakamany) and greengram (Mg 161) were selected for ascertaining the influence of different processing and cooking treatments on the cooking, nutritional and antinutritional characteristics of these two pulses.

Different processing and cooking treatments were found to influence the cooking qualities and nutritional composition of pulses. However, antinutrients such as phytic acid, tannin, trypsin inhibitor and oligosaccharides which hinder the efficient utilisation, absorption or digestion and bioavailability of nutrients are reported to be removed or reduced by simple processing and cooking methods.

Effect of processing on cooking qualities of Kanakamany and Mg 161 (Tables 22 and 23).

Cooking characteristics of pulses such as cooking time, water uptake, leaching loss and volume expansion as influenced by different processing and cooking methods were assessed. Consumers prefer maximum increase in cooked weight and volume with a minimum cooking time. Cooking of pulses for long period results in increased fuel consumption which is wasteful and is also a constraint in the rural households. It also results in reduction of nutrients by lowering the availability of lysine and biological value. Processing and cooking treatments are reported to influence the cooking characteristics.

Cooking time of Kanakamany ranged from 10.58 to 59.87 minutes in different processing and cooking treatments. As indicated in Table 22 time taken to cook Kanakamany by pressure cooking method (10.58 minutes) was significantly lower than other cooking methods. Time taken to cook Kanakamany by steaming (T_4) 59.87 minutes) and boiling methods (T_2) (47 minutes) were significantly higher than other cooking methods. Soaking prior to cooking helped to reduce cooking time significantly. Soaking prior to boiling (T_3) and soaking and or germination prior to steaming (T_6 and T_8) were found to reduce cooking time significantly. Time taken to cook Kanakamany by different methods like soaking and boiling (T_3) (25.45 minutes), soaking and steaming (T_6) (30.23 minutes) and germinating and steaming (T_8) (27.02 minutes) were comparable among the processing and cooking methods studied.

Table 22 Influence of processing and cooking on the cooking characteristics of Kanakamany

Processing and cooking methods	Cooking time minutes	water uptake per cent	Leaching Loss per cent	Volume expansion per cent
2. Boiling	47.00	154.00	12.97	114.00
3. Soaking and Boiling	25.45	169.67	10.53	125.67
4. Steaming	59.87	52.33	—	41.67
5. Pressure cooking	10.58	201.33	—	155.33
6. Soaking and steaming	30.23	92.00	—	116.67
7. Germination	—	145.00	002.03	152.67
8. Germination and steaming	26.62	132.33	002.03	119.33
F	117.83**	98.85**	230.02**	13.39
SE	01.61	04.987	00.376	10.258
CD	04.958	15.128	01.225	—

**** Significant at 5 per cent level**

Cooking time	T_4	T_2	T_6	T_8	T_3	T_5	
water uptake	T_5	T_3	T_2	T_7	T_8	T_6	T_4
Volume expansion	T_5	T_7	T_3	T_8	T_6	T_2	T_4
Leaching loss	T_2	T_3	T_7	T_8			

For Mg 161, cooking time ranged from 8.32 minutes to 51.83 minutes. Time taken to cook Mg 161 varied significantly in different cooking methods. Cooking time was lowest in pressure cooking (T_5), 8.32 minutes which was significantly lower than other methods. Cooking time was highest in steaming method (T_4) 51.83 minutes) followed by boiling (T_2) 33.73 minutes). Time taken to cook Mg 161 by steaming 51.83 minutes) and boiling 33.73 minutes) were significantly higher than other methods. Cooking time in pressure cooking 8.32 minutes) and boiling of soaked Mg 161 (T_3) (19.58 minutes) were significantly lower

than all other methods. Soaking before steaming (T_6) (27.33 minutes) and germination before steaming (T_8) (24.55 minutes) were comparable when cooking time was counted.

Table 23 Influence of processing on the cooking characteristics of Mg 161

Processing and cooking methods	Cooking time minutes	water uptake per cent	Leaching loss per cent	Volume expansion per cent
2. Boiling	33.73	184.00	09.27	133.33
3. Soaking and Boiling	19.58	142.00	11.50	144.33
4. Steaming	51.83	89.33	—	51.00
5. Pressure cooking	08.32	188.67	—	141.67
6. Soaking and steaming	27.33	102.67	—	115.33
7. Germination	—	222.33	03.00	241.67
8. Germination and steaming	24.55	159.67	03.00	225.00
F	154.82**	66.77**	427.59**	82.93**
SE	01.176	05.858	00.211	07.15
CD	03.624	17.77	00.687	21.68

**** Significant at 5 per cent level**

Cooking time	T_4	T_2	T_6	T_8	T_3	T_5	
Water uptake	T_7	T_5	T_2	T_8	T_3	T_6	T_4
Volume expansion	T_7	T_8	T_3	T_5	T_2	T_6	T_4
Leaching loss	T_3	T_2	T_7	T_8			

Eventhough the time taken to cook Kanakamany differ from that of Mg 161, processing and cooking treatments have almost the same effect on both pulses.

As revealed from the results soaking before cooking helped to decrease the cooking time significantly. Germination further reduced the cooking time than the process of soaking.

Phirke et al., 1982; Kailasapathy and Koneshan 1986; and Bakr and Gawish 1992; had reported that soaking in water for 12 hours reduced the cooking time in various types of seeds. Time required for cooking is appreciably shortened by sprouting in which the thick outer coat bursts open and the grains becomes soft making it easier for the cooking water to penetrate the grain.

Consumers will have greater preference for the grains,m with the least cooking time. In that content pressure cooking can be considered as ideal method of cooking pulses.

Water uptake, is the utilization of water by the pulses during the process of cooking. As indicated in the Table 22, water uptake of Kanakamany ranged from 52.33 per cent to 201.33 per cent in different processing and cooking methods.

Water uptake was highest when grains were pressure cooked (201.33 per cent) and it was significantly higher than for other processing and cooking methods. Water uptake in two processing methods like boiling (T_2-154.00 per cent) and germination (T_7-145 per cent) were also found to be higher. There was no significant variation in water uptake when the germinated grains were cooked by steaming (T_8-132.33 per cent) when compared with germinated uncooked Kanakamany samples (T_7-145 per cent).

Water uptake was lowest in Kanakamany cooked by steaming (T_4-52.33 per cent). While water uptake was significantly higher when the soaked grains were steamcooked (T_6-92.00 per cent), when compared to unsoaked steamed samples T_4-52.00 per cent).

Water uptake of Mg 161 ranged from 89.33 per cent in pressure cooking (T_5) to 233.33 per cent in germination (T_7). There was significant variation in water uptake among the different processing and cooking methods studied. Germinated samples (T_7) recorded the highest water uptake (222.33 per cent) followed by samples cooked under pressure cooking (T_5 - 188.67 per cent). However, water uptake of the samples (T_5 - 188.67 per cent) were on par with the boiled samples (T_2 -184 per cent). When the germinated grains were cooked by steaming (T_8) water uptake (159.67 per cent) was significantly lower than in germinated samples (222.23 per cent). Water uptake in

Germinated and steamed sample (T_8) were comparable with soaked and (T_3 - 142 per cent) and soaked and steamed samples (T_3 - 142 per cent). Water uptake of soaked and steamed samples 102.67 per cent) were comparable with steamed samples (T_4 - 89.33 per cent) of unsoaked samples.

As revealed from the results water uptake depends on the method of cooking in water media and soaking and germination prior to cooking were found to results in higher water uptake by the cooked samples. Leaching loss of pulses during processing and cooking was another phenomenon assessed with two samples only cooking or processing in the water medium leads to leaching loss. Leaching loss of Kanakamany during cooking ranged from 2.03 to 12.97 per cent. The leaching loss was lowest for germination (2.03 per cent) and germinated and steamed samples. Leaching loss was highest in boiled samples (T_2 - 12.97 per cent) and it was significantly higher than for soaked and boiled samples (T_3 - 10.53 per cent).

In Mg 161 leaching loss ranged from 3.00 per cent to 11.50 per cent. Leaching loss was highest when the grains were boiled after soaking (11.5 per cent) and this was significantly higher than the loss observed in boiled samples (T_2 - 9.27 per cent).

As revealed from the results soaking before cooking decreased the leaching loss in Kanakamany, whereas it increased leaching loss in Mg 161.

Volume expansion of pulses during processing and cooking methods were assessed. In Kanakamany, volume expansion of the cooked grains ranged from 41.67 per cent to 155.33 per cent in different methods of cooking. Volume expansion was highest in pressure cooked samples (T_5 - 155.33 per cent) which was on par with germinated sample (T_7 - 52.67 per cent) and soaked and boiled samples (T_3 - 125.00 per cent). Lowest volume expansion was recorded for steamed samples (T_4 - 41.67 per cent) and this was significantly lower than all other processed and cooked samples. Volume expansion of samples due to soaking and boiling (T_3 - 125 per cent) germination and steaming (T_8 - 119.33 per cent) and soaking and steaming (T_6 - 116.67 per cent) and boiling (114.00 per cent) were also found comparable.

Volume expansion in Mg 161 after processing and cooking methods ranged from 51 per cent to 241.67 per cent. Volume expansion of the processed sample was highest in germinated Mg 161 (T_7 - 241.67 per cent) followed by germinated and steamed samples (T_8 - 225 per cent) values of which were comparable but significantly higher than other samples. Volume expansion was lowest in steamed samples (T_4 - 51 per cent) and this was significantly lower than all other methods (T_5 - 58.33 per cent). Volume expansion during boiling (T_2 - 133.33 per cent) was comparable with soaking and steaming (T_6 - 115.33 per cent). Soaking and boiling (T_3 - 144.33 per cent), pressure cooking (T_5 - 141.67 per cent) and boiling (T_2 - 133.33 per cent) were comparable. As revealed from the results moist methods of cooking and processing were found to increase volume expansion. Germination and soaking increased the volume of grains but steaming after these processing reduced the volume expansion mainly due to the evaporation of excess water from the grains during steaming.

Bakr and Gawish (1992) reported increased volume expansion in seeds soaked before cooking.

Influence of processing and cooking on the nutritional composition of Kanakamany and Mg 161 (Tables 24 and 25).

Data on retention of nutrients after cooking would be more useful than proximate composition data of raw food crops. In this study effect of different processing and cooking methods on the protein, calcium and iron content of Kanakamany and Mg 161 were assessed.

Among the various processing techniques administered, germination was found to have positive influence on the protein content. Protein content of Kanakamany was highest in germinated.

Kanakamany (27.52 per cent) followed by germinated and steamed Kanakamany (25.11 per cent. Germination has helped to increase protein content but this enhancement was negatively affected by steaming. Protein content of steamed Kanakamany (24.67 per cent)

Table 24 Influence of processing and cooking on the nutritional composition of Kanakamany-

Processing and cooking methods	Protein g per cent	Calcium mg per cent	Iron mg per cent
1. Raw Samples	24.06	223.67	12.30
2. Boiling	23.19	126.67	08.77
	(03.60)	(43.45)	(28.70)
3. Soaking and Boiling	21.17	141.00	08.50
	(12.01)	(37.05)	(30.89)
4. Steaming	24.69	131.67	09.73
	(02.62)	(41.22)	(20.89)
5. Pressure cooking	23.86	112.67	09.50
	(00.83)	(49.70)	(22.76)
6. Soaking and steaming	23.40	182.67	09.50
	(0.83)	(49.70)	(22.76)
7. Cermination	27.52	191.33	9.07
	(14.38)	(14.58)	(26.26)
8. Germination and	25.11	204.33	08.70
steaming	(04.36)	(08.78)	(29.27)
F	73.67**	185.59**	58.42**
SE	0.211	3.023	0.161
CD	0.633	9.064	0.483

**** Significant at 5 per cent level**

Figures in parenthesis indicates percentage

Protein	T_7	T_8	T_4	T_1	T_5	T_6	T_2	T_3
Calcium	T_1	T_8	T_7	T_6	T_3	T_4	T_2	T_5
Iron	T_1	T_4	T_5	T_7	T_6	T_2	T_8	T_3

was also higher than raw Kanakamany (24.06 per cent), but the difference was not significant. Protein content of germinated Kanakamany was on par with germinated and steamed Kanakamany while protein content of germinated and steamed Kanakamany was on par with steamed Kanakamany. Other processing and cooking methods like boiling, soaking and boiling, pressure cooking and soaking and steaming were observed to reduce the protein content. Protein content of pressure cooked Kanakamany was 23.86 and this was lower than the protein content of raw grains, but the reduction in protein content during pressure cooking was not significant when compared with raw grains. Pressure cooking was on par with soaking and steaming (T_6) in the retention of the protein content (23.40 per cent). In cooked samples protein content of boiled Kanakamany (T_2 - 23.19 per cent) was further lowered but this was on par with soaking and steaming. Boiling of soaked Kanakamany caused maximum loss in protein content (21.17 per cent) The protein content of soaked and boiled samples was significantly lower than protein content of boiled Kanakamany (T_2 - 23.19 per cent).

Influence of different processing and cooking methods on the nutrient composition of Mg 161 was also assessed and the effect was almost same as that of Kanakamany. Protein content of Mg 161 was enhanced better during germination (T_7 -23.47 per cent) followed by the germination and steaming Mg 161 (T_8 - 23.11 per cent). Increase in protein content by these processing methods were also comparable. Protein content of steamed (T_4) Mg 161 (22.34 per cent) was lower than germinated and steamed sample. However, the protein content of these two samples were comparable. Steaming was also observed to increase the protein content when compared with raw Mg 161 (212.86 per cent), but the increase in protein content during steaming was not significantly higher than raw Mg 161. Other processing and cooking method reduced the protein content even though a comparison with the raw Mg 161 revealed that the reduction was not statistically significantly during pressure cooking and soaking and steaming. Protein content in pressure cooked (T_5) Mg 161 was 21.78 per cent) and Mg 161 samples soaked and steamed (T_6) were found to have 21.42 per cent protein. The protein content of pressure cooked and soaked and steamed samples were on par with raw Mg 161. Soaking and boiling further reduce the protein

content and the protein content of soaked and boiled Mg 161 was 21.02 per cent, which was on par with soaked and steamed Mg 161 (21.42 per cent). Protein content was lowest in boiled Mg 161 (20.49 per cent) but the protein loss in boiled Mg 161 was on par with soaked and boiled Mg 161.

Table 25 Influence of processing and cooking on the nutritional composition of Mg 161

Processing and Cooking methods	Protein g per cent	Calcium mg per cent	Iron mg per cent
1. Raw Samples	21.86	261.33	12.63
2. Boiling	20.49 (06.27)	203.67 (21.97)	08.67 (31.19)
3. Soaking and Boiling	21.02 (03.84)	224.67 (13.92)	08.83 (29.92)
4. Steaming	22.34 (02.19)	238.33 (08.69)	09.10 (27.78)
5. Pressure cooking	21.78 (00.37)	242.67 (07.02)	10.10 (19.84)
6. Soaking and steaming	21.42 (02.01)	230.33 (11.75)	09.33 (25.95)
7. Germination	23.47 (07.37)	241.00 (07.66)	09.50 (24.60)
8. Germination and steaming	23.11 (05.72)	244.33 (06.39)	08.90 (29.37)
F	13.17**	35.88**	152.57**
SE	00.277	02.816	00.10
CD	00.832	08.443	00.314

**** Significant at 5 per cent level**

Figures in parenthesis indicates percentage

Protein	T_7	T_8	T_4	T_1	T_5	T_6	T_3	T_2
Calcium	T_1	T_8	T_5	T_7	T_4	T_6	T_3	T_2
Iron	T_1	T_5	T_7	T_6	T_4	T_8	T_3	T_2

Results of the study revealed variation in protein content during processing and cooking. Percentage difference in protein content during processing and cooking were worked out and presented in the Tables 24 and 25. As indicated from the ranking order among the difference processing and cooking methods germination (T_7), germination and steaming (T_8) and steaming (T_4) was found to enhance the protein content when compared with raw Kanakamany and Mg 161.

Germination was found to have maximum enhancement in protein content and the increase was 14.38 per cent in Kanakamany and 7.37 per cent in Mg 161. Increase in protein content during germination may be due to formation of enzymatic proteins.

In earlier studies the protein content of legumes were reported to increase during germination (Kylen and mc cready 1975; Fordham et al 1975., Hsu et al 1980., Aughustin and Kelin 1989; and Sylvestor et al 1994). This increase in protein content is ambiguous and may be due to an increase in the non protein nitrogen as reported by EL-Shimi et al (1984). Ohizoba (1992) observed and increase in crude protein, true proteins, total nitrogen and total non-protein nitrogen after 48 hours of sprouting. Increase in protein during sprouting originates mainly from synthesis of enzymatic protein (Vander stope 1981). This increase in protein was observed to be accompanied by a decrease in carbohydrate and food energy.

Steaming of germinated pulses decreased the protein content eventhough the protein content of these samples were significantly higher than raw pulses, the difference being 4.36 per cent in Kanakamany and 5.72 per cent in Mg 161. The loss in protein during steaming of germinated sample was not statistically significantly when compared to germinated samples.

Steaming of unprocessed pulses were found to increase the protein content by 2.62 per cent in Kanakamany and 2.19 per cent in Mg 161, eventhough the increase was not statistically significantly. This increase may be probably be due to the release of bound protein during heat processing.

Pressure cooking was found to reduce the protein content by 0.83 per cent in

Kanakamany and 0.37 per cent in Mg 161. The loss in protein content during pressure cooking was not statistically significant.

Even though steaming was found to cause an increase in protein content, soaking prior to steaming decreased the protein content. The loss was 2.74 per cent in Kanakamany which was statistically significant when compared with raw Kanakamany. The loss was 2.0 per cent in Mg 161 and it was not statistically significant. The decrease in protein during soaking may probably to due to leaching losses.

Srivasthava et al. 1988 reported that soaking in solution of sodium bicarbonate caused leaching of sugars and protein resulting in decrease in starch and protein content in seeds.

As in the case of steaming soaking before boiling further reduced protein content. Loss in protein content during boiling was 3.60 per cent, whereas it become 12.01 per cent in soaked and boiled Kanakamany. Retention of protein during boiling was on par with soaking and steaming whereas the retention was significantly lower in soaked and boiled Kanakamany when compared with boiled Kanakamany.

In Mg 161 loss in protein was 3.84 per cent during soaking and boiling and the protein retention was on par with soaking and steaming. Loss in protein content was 6.27 per cent in boiled Mg 161 and retention was on par with soaked and boiled Mg 161.

As revealed from the study there was an increase in protein content during germination a nd steaming. Whereas heat treatment of soaked and germinated pulses reduced the protein content. Moist method of cooking was also found to cause loss in protein content. This may probably be due to the leaching of solids into the water use for cooking.

Processing and cooking were found to reduce the mineral content of pulses. Retention due to cooking was higher only for proteins, fat and carbohydrate.

Among minerals phosphorus retention was highest followed by calcium, zinc, manganese and iron. Influence of different processing and cooking methods on the calcium and iron content in Kanakamany and Mg 161 were assessed.

As indicated in Tables 24 and 25 processing and cooking of Kanakamany and Mg 161 resulted in the reduction of calcium. Calcium content of raw Kanakamany was 223.67 mg per cent and as a result of processing it was reduced to 112.67 per cent, during pressure cooking Calcium retention was higher in germinated and steamed Kanakamany (204.23 per cent). All the processing and cooking methods administered were found to cause significant loss in calcium, except in the germinated and steamed Kanakamany samples (8.78 per cent). Loss in calcium during germination (T_7) was 14.58 per cent and soaking followed by steaming (T_6) of the Kanakamany caused 18.60 per cent loss. Calcium retention in germinated (T_7) and soaked and steamed (T_6) samples were comparable ie. the loss in calcium during these two treatments were not statistically significant. Loss of calcium in Kanakamany during soaking followed by boiling was 37.05 per cent and calcium retention was significantly lower than the samples under T_8, T_7 and T_6. However, the rate of retention in this group was significantly higher than in those under T_4, T_2 and T_5. Loss in calcium during steaming (T_4) was 41.22 per cent and this was on par with boiling (T_2) where the loss was 43.45 per cent.

Calcium retention was lowest in pressure cooked Kanakamany and was significantly lower than all other processing and cooking methods. The loss in Calcium during pressure cooking was 49.70 per cent.

In Mg 161 also various processing and cooking treatments reduced calcium content significantly. Calcium content of raw Mg 161 was 261.33 mg per cent and was reduced from 203.67 mg per cent to 244.33 mg percent due to various processing and cooking treatments. Maximum calcium loss of 21.97 per cent was observed in boiled green gram while it was minimum in germinated and steamed Mg 161 (6.39 per cent). Calcium retention in germinated steamed sample was on par with pressure cooked, germinated and steamed Mg 161. Calcium loss was 6.39 per cent in germinated and steamed samples 7.02 per cent in pressure cooked samples, 7.66 per cent in germinated samples and 8.69 per cent in steamed samples. Calcium loss during soaking and steaming was 11.75 per cent and calcium retention of this samples was on par with steamed as well as soaked and boiled Mg 161.

Loss in calcium during soaking and boiling was 13.92 per cent. Calcium retention was lowest in boiled Mg 161, where the loss was 21.97 per cent.

As revealed from the result and ranking order there was significant variation in calcium content due to processing and cooking. The effect of processing on Kanakamany was observed to differ from that of Mg 161.

Rao and Deosthale (1983) reported that cooking of raw pulse grains resulted in significant loss of minerals. Loss in calcium during wet cooking and soaking and soaking may be higher because the seed coat of pulses gets disrupted during soaking and the cotyledons of the grains were exposed and loss occurred.

Processing and cooking methods were found to reduce the iron content in pulses. Iron content of raw Kanakamany was 12.30 mg per cent and during processing and cooking it was reduced from 8.50 per cent to 9.73 mg percent. Maximum retention of iron was observed in steamed samples (T_4), where the loss was 20.89 per cent. Iron retention of steamed Kanakamany was on par with the pressure cooked Kanakamany. Loss in iron during pressure cooking was 22.76 per cent. Iron retention of pressure cooked Kanakamany was on par with germinated Kanakamany where the loss was 26.26 per cent. Germinated Kanakamany was on par with soaked and steamed Kanakamany in retention. Loss during soaking and steaming was 27.89 per cent. Loss in iron was 28.70 per cent in boiled samples 29.27 per cent in germinated and steamed samples and 30.89 per cent in soaked and boiled samples. Calcium retention during soaking and steaming, boiling, germination and steaming and soaking and boiling of Kanakamany were not statistically significant.

Different processing and cooking methods studied were found to cause significant loss in iron content in Mg 161. Iron content in Mg 161, was 12.30 mg per cent. This was reduced in the range of 10.10 mg per cent during various processing and cooking methods. Maximum retention of iron was observed during pressure cooking. Loss during pressure cooking was 19.84 per cent and the loss was statistically significant. Germinated Mg 161 was found to cause 24.60 per cent loss in iron. Iron retention was significantly lower for germination when compared with pressure cooking. Iron loss in soaked and steamed Mg

161 was 25.95 per cent and the loss was on par with that of steamed Mg 161, where the loss was 27.78 per cent. Retention of iron during steaming was on par with germinated and steamed samples where the loss was 29.37 per cent. Loss in iron was 29.92 per cent in soaked and boiled Mg 161 and 31.19 per cent in boiled Mg 161. Loss in iron during germination and steaming, soaking and boiling and boiling were not statistically significant.

Influence of processing and cooking on the antinutritional factors in Kanakamany and Mg 161 (Tables 26 and 27)

Antinutritional factors in pulses may survive the domestic processing and cooking treatments and finally remains in the food, when it reaches the consumers table. Changes in tannin, phytin, trypsin inhibitor and oligosaccharides of pulses due to various processing and cooking treatments were investigated.

As indicated in Table 23 and 24 different processing and cooking methods were found to cause significant reduction in antinutritional factors. Padma and Sumathi (1994) also reported significant reduction of antinutritional factors by various cooking treatments.

Tannin content of raw Kanakamany was 538.33 per cent and it was reduced from 286.00 to 424.67 per cent due to different processing and cooking treatments. Loss in the tannin content was maximum (46.84 per cent) when the samples were soaked and boiled (T_3) and this loss was significantly higher, when compared to other processing and cooking methods. Germination followed by steaming (T_8) was the next best method to reduce tannin (42.01 per cent) which was comparable with boiling (T_2) unsoaked Kanakamany in which case the loss was around 40.02 per cent. Germination (T_7) and steaming (T_4) were found to reduce tannin by 25.78 per cent and 28.13 per cent respectively and there was no significant difference between germinated (T_7) and steamed (T_4) Kanakamany in the tannin loss soaking and steaming caused 32.78 per cent reduction in tannin and the loss was significantly lower than the samples as T_2, T_8 and T_3 and the loss was higher than the samples in T_5, T_7 and T_4. Loss in tannin content was minimum (21.06 per cent) in pressure cooking (T_5). However,the tannin content in this sample was significantly lower than in raw Kanakamany.

Table 26 Influence of different processing and cooking on the antinutritional composition of Kanakamany--

Processing and cooking methods	Tannic acid mg per cent	Phytic acid mg per cent	Trypsin inhibitor TIU/mg
1. Raw samples	538.33	387.33	38.48
2. Boiling	322.67	286.33	09.67
	(46.84)	(34.14)	(79.05)
3. Soaking and Boiling	286.00	251.00	08.06
	(46.84)	(35.14)	(79.05)
4. Steaming	386.67	319.00	13.17
	(28.13)	(17.57)	(65.77)
5. Pressure cooking	242.67	265.33	12.76
	(21.06)	(31.44)	(66.84)
6. Soaking and steaming	361.67	276.00	12.93
	(32.78)	(28.68)	(66.84)
7. Germination	399.33	302.67	14.07
	(25.78)	(21.79)	(63.43)
8. Germination and steaming	312.00	292.66	10.72
	(42.01)	(24.37)	(72.14)
F	197.63**	134.76**	1108.38**
SE	05.675	03.621	00.292
CD	17.015	10.855	00.874

** Significant at 5 per cent level

Figures in parenthesis indicates percentage

Tannic acid	T_1	T_5	T_7	T_4	T_6	T_2	T_8	T_3
Phytic acid	T_1	T_4	T_7	T_8	T_2	T_6	T_5	T_3
Trypsin inhibitor	T_1	T_7	T_4	T_6	T_5	T_8	T_2	T_3

Assessment of tannin content in processed and cooked Kanakamany revealed that all methods of processing and cooking studied were effective in reducing the tannin.

In raw Mg 161 tannin content was 316.67 per cent and this was reduced from 212.00 to 298 per cent due to different processing and cooking treatments. Maximum loss in tannin content (33.12 per cent) was observed in soaked and boiled green gram (T_3) which was significantly lower than the tannin content of other processed and cooked samples. Loss in tannin content during boiling was 21.77 per cent, and this was on par with the tannin content of steamed samples (T_4) where the loss was 18.29 per cent. During soaking and steaming tannin loss wa 13.25 per cent and this was on par with the tannin content of cooked samples where the loss was 9.46 per cent. Loss in tannin content was minimum during germination (T_7 - 5.99 per cent) and was on par with germination and steaming (T_8 - 7.26 per cent) and pressure cooking (T_5 - 9.46 per cent). Significant loss in tannin content was observed during various processing and cooking methods studied.

Different treatments where ranked in the descending order based on the content of tannin after processing and cooking treatment. Influence of various treatments on Kanakamany was different from that of Mg 161. For both Kanakamany and Mg 161 soaking and boiling was the most effective method in reducing the tannin content. Polyphenols are present in the periphery of the seed and the loss during soaking and wet cooking may probably be due to their passing out into the cooking medium. Marked reduction in tannin due to soaking was reported by Bishnoi et al (1994) in peas. Deshpande and Cheryan (1983) and Kataria et al (1989) also reported similar results for various legumes including rice bean and mug bean. Boiling, steaming and pressure cooking were found to reduce the tannin content considerably and soaking and or germination before cooking further reduced tannin content. As revealed in the ranking order soaking and boiling wa better than boiling of unsoaked pulses (T_2) and soaking and steaming (T_6) was more effective than steaming (T_4); and germination and steaming (T_8) was effective than germination alone (T_7). Binding of polyphenol with other organic substances and protein or alteration in the chemical structure of polyphenols which can not be extracted by

Table 27 Influence of Processing and cooking on the antinutrional composition of Mg 161

Processing and Cooking methods		Tannic acid mg per cent	Phytic acid mg per cent	Trypsin inhibitor TIU/mg
1.	Raw samples	316.67	209.67	55.74
2.	Boiling	248.00 (21.77)	108.00 (13.88)	05.34 (90.42)
3.	Soaking and Boiling	212.00 (33.12)	139.00 (33.49)	04.09 (92.66)
4.	Steaming	259.00 (18.29)	195.00 (06.70)	07.37 (86.78)
5.	Presure cooking	287.00 (09.46)	151.33 (27.75)	06.70 (87.98)
6.	Soaking and Steaming	275.00 (13.25)	123.33 (41.15)	07.18 (87.12)
7.	Germination	298.00 (05.99)	179.00 (14.35)	11.33 (79.67)
8.	Germination and Steaming	294.00 (07.26)	172.33 (17.70)	04.88 (91.25)
	F	59.35**	90.76 **	2352.49**
	SE	04.304	03.032	00.360
	CD	12.906	09.091	01.080

** Significant at 5 per cent level

Tannic acid	T_1	T_7	T_8	T_5	T_6	T_4	T_2	T_3
Phytic acid	T_1	T_4	T_2	T_7	T_8	T_5	T_3	T_6
Trypsin inhibitor	T_1	T_7	T_4	T_6	T_5	T_2	T_8	T_3

available methods may explain a decrease in tannin of the legume grains during cooking. According to Bishnoi and Yadav (1992) germination have a marked lowering effect on polyphenolic compounds with an increase in the period of germination losses of the constituents were also observed to increase.

Tannin content of germinated and steamed Kanakamany was significantly lower than soaked and steamed Kanakamany. Before germination, soaking was also done and some loss of polyphenols during soaking was also expected because of its leaching into the soaking water. Further decrease in tannin contents during germination may be attributed to the presence of polyphenols oxidize and enzymatic hydrolysis. (Jood and Kapoor 1987; and Rao and Deosthule 1982).

Processing and cooking methods were found to reduce phytic acid content in Kanakamany and Mg 161. Phytic acid content of dry Kanakamany was 387.33 mg percent. Phytic acid was reduced from 251 mg per cent to 302.67 mg per cent due to various processing and cooking methods. Maximum loss in phytic acid content was observed in soaking and boiling (T_3 - 35.14 per cent) and the loss was significantly higher than in other samples processed and cooked by different methods. Loss in phytic acid during pressure cooking (T_5) was 31.44 per cent and this was on par with soaked and steamed samples (T_6) where the loss was 28.68 per cent. Loss during soaking and steaming (T_6) was on par with boiling (T_2) where the loss was 26.01 per cent. Loss in phytic acid during germination (21.79 per cent) was on par with germinated and steamed samples where the loss was 24.37 per cent.

Minimum loss in phytic acid (17.57 per cent) was observed in steamed samples (T_4) but the phytic acid content was significantly lower than in raw Kanakamany.

Phytic acid content in Mg 161 was 209.67 per cent. Phytic acid was reduced from 123.33 per cent to 194.67 per cent due to various processing and cooking methods. Loss in phytic acid was maximum due to soaking and steaming (T_6 - 41.15 per cent) and the loss was significantly higher than in other methods. Phytic acid loss was 33.49 per cent in soaked and boiled Mg 161 (T_3) and 27.75 per cent in pressure cooked Mg 161 (T_5) and the variation between the two were statistically significant. Percentage loss in phytic acid

during germination and steaming (T_8) was 17.70 per cent which wa on par with germinated and boiled samples where the loss was 14.35 per cent (T_7) and 13.88 per cent respectively.

Results of the study revealed that all processing and cooking methods studied were effective in reducing the phytic acid present in Kanakamany and Mg 161. Influence of various treatments on Kanakamany was significantly different from that of Mg 161. Different treatments are ranked in the descending order based on the pre cent loss in phytic acid. Loss in phytic acid may be because of leaching of phytate ions into soaking water, leaching losses may be taken as a function of changed permeability of seed coat and absorption of water in seeds may also activate phytase resulting in hydrolysis and hence loss of phytic acid. Bishnoi and Yadav (1993) reported that soaking contributed significantly towards the loss of phytic acid content and with longer periods of soaking the losses in phytate content as noticed in peas were greater. Similar results for reduction in phytic acid in the soaked legumes have been reported earlier by Deshpande and Cheryan (1983) Ologhobo and Fetuga (1984) and Santhosh and Chavan (1986).

Steaming or boiling germinated or soaked grains were more effective the reducing phytic acid than steaming or boiling of unsoaked or ungerminated grains. Cooking brought about a significant decrease in phytic acid content and the loss appeared to be more in soaked and cooked grains than in unsoaked and cooked grains as reported by Kataria et al (1989) Bishnoi et al., (1994) and Sylvester et al. (1994). Similar reduction in phytic acid content during the combined process of soaking and cooking has been reported in legumes like moth and faba bean by (Iyer et al (1980), Khokhar (1984), Kataria et al. (1989), Sharma (1989) and Sylvester et al. (1994).

Boiling and pressure cooking may be attributed to the formation of insoluble complexes between phytate and other component. This may be reason for the significant reduction in phytic acid content during cooking. Boiling of soaked grains showed a further lowering of phytic acid content which is attributed to leaching into the water.

Germination was found to cause significant reduction in phytic acid and this may be due to hydrolytic activity of phytase reported to be present in various plant food. Boiling of sprouts significantly lowered the phytic acid content in legumes which may be due to a combination of the initial loss of soaking, increased phytase activity on sprouting and the heat treatment applied to the seeds of boiling.

Germination also resulted in a significant reduction of phytic acid in black gram (Reddy et al., 1978; in Kanakamany, soyabean and lima bean (Ologhobo and Fetuga 1984) and in field and vegetable pea and as the period of germination increased, successive redaction in phytic acid content was observed in peas by Bishnoi and Yadav (1993).

Influence of processing and cooking on the trypsin inhibitor content of Kanakamany and Mg 161 were assessed. Trypsin inhibitor activity of raw Kanakamany was 38.48 TIU/mg. During processing and cooking trypsin Inhibitor activity was reduced from 8.06 TIU/mg to 14.07 TIU/mg. Loss in trypsin inhibitor activity was highest in soaked and boiled Kanakamany (T_3) and the per cent loss was around 79.05 per cent followed by boiled Kanakamany (T_2) where the loss was 74.87 per cent. This difference in percentage loss between T_3 and T_2 were statistically significant. Loss in trypsin inhibitor activity was minimum in germinated samples (63.44 per cent) which was on par with steamed samples (T_4) a percentage loss of 65.77 per cent. Loss in trypsin inhibitor activity during steaming (T_4) was on par with soaking and steaming (66.40 per cent) and pressure cooking (66.84 per cent). During germination and steaming (T_8) the loss of trypsin inhibitor activity was 72.14 per cent. The loss was significantly lower than the loss of T_3 and T_2 (boiling of soaked and unsoaked pulses) where as it was significantly lower than other processing methods.

Trypsin inhibitor activity of Mg 161 was 55.74 TIU/mg and was reduced from 4.09 to 11.33 TIU/mg after various processing and cooking methods. The loss in trypsin inhibitor activity was highest in soaking and boiling (T_3). This loss was on par with the losses of samples under went germination and steaming (T_8). Percentage loss was 92.66 per cent in (T_3) and 91.25 per cent in T_8. Similarly TIA loss due to germination and steaming (T_8) was on par with boiling (T_2) where the loss was 90.42 per cent. Minimum loss of trypsin

inhibitor activity was observed in germinated Mg 161 (T_7) and the percentage loss was 79.67 per cent. Where the activity was significantly lower when compared to raw Mg 161. Loss in trypsin inhibitor activity during steaming (T_4), soaking and steaming (T_6) and pressure cooking (T_5) were not significantly different. Loss was 87.98 per cent in T_5 (pressure cooking), followed by 87.12 per cent in T_6 (Soaking and steaming) and 86.78 per cent in T_4 (steaming).

Various processing and cooking treatments reduced trypsin inhibitor activity significantly and the different treatments were ranked in the descending order based on the trypsin inhibitor activity. Assessment of the results revealed that loss in trypsin inhibitor activity of germinated samples were greater than germinated and steamed samples. Loss in trypsin inhibitor activity was more in soaked pulses due to boiling than in boiling the unsoaked samples. This revealed that combination of processing and heat treatments reduced trypsin inhibitor activity significantly.

Since trypsin inhibitors are low molecular proteins, their extraction from the seed to the soaking medium is quite possible and this may be the reason for the losses of trypsin inhibitor activity during soaking. Loss of trypsin inhibitor activity during various cooking and processing methods may be die to the well established heat labile nature of trypsin inhibitors, and heat application is expected to denature the protenaceous trypsin inhibitor.

Subhalakshmi et al. (1976) reported 378 per cent loss in trypsin inhibitor activity on germination of month bean seeds. Santhosh and Chauhan (1986) also reported similar findings and the reduction may be attributed to the mobilization and enzymatic degradation of proteins including trypsin inhibitors of seeds during germination. Soaking boiling and pressure cooking of sprouts are reported to eliminated trypsin inhibitor activity from month bean (Santhosh and Chauhan 1986). Cooking was also reported to be effective in activating protease inhibitors in several food legumes (Manorama and Sarojini 1982; Tan and Wong 1982; Olohobo and Fetuga 1983 and Gupta and Wagle 1980).

Influence of processing and cooking on the oligosaccharides in Kanakamany and Mg 161 (Table 28).

Legumes are reported to contain raffinose family oligosaccharides which have the tendency to induce flatulence (Sugimoto and Van Buren 1970). Influence of different processing and cooking on the oligosaccharides content were assessed.

Kanakamany contained 0.48 per cent raffinose which was reduced to 0.39 to 0.20 per cent after the administration of processing and cooking methods. Loss in raffinose was highest in germinated samples when steamed (T_8 - 58.33 per cent). Raffinose content in germinated and steamed (T_8) Kanakamany was on par with germinated samples in raw form (T_7) where the loss was 52.08 per cent. Other treatments such as pressure cooking (T_5) and soaking and boiling (T_3) helped to reduce the raffinose content by 45.83 per cent (T_5) and 39.58 per cent (T_3). By during pressure cooking was higher than when they were soaked and boiled. However, the raffinose content between these two were comparable. Raffinose content in soaked and steamed (T_6) Kanakamany was on par with boiled Kanakamany (T_2), where the loss was 31.25 per cent (T_6) and 25 per cent (T_2) respectively. Loss in raffinose of Kanakamany was minimum while steaming (T_4 - 18.75 per cent). Raffinose content was significantly lower in all these treated samples when compared to unprocessed Kanakamany. Raffinose loss was 18.75 per cent in steamed Kanakamany followed by boiled, where 25 per cent loss was observed.

Effect of processing and cooking on the raffinose content of Mg 161 were also assessed. The raffinose content in the raw Mg 161 was 0.71 per cent which was reduced to 0.38 to 0.66 per cent during processing and cooking treatments. As in the case of Kanakamany the loss in raffinose was maximum in T_8 (Germination and steaming 46.48 per cent) and the raffinose content was significantly lower than that of germinated Mg 161 in raw form (T_7 - 35.21 per cent). This indicated the loss in raffinose during heat processing. During pressure cooking the loss of raffinose was found to be 28.17 per cent while only 12.68 per cent loss in raffinose was observed in boiled Mg 161 samples. Loss in raffinose during soaking and steaming (T_6) was 18.31 per cent and the raffinose content in T_5 was on par

with soaked and boiled samples (T_3) where the loss was 22.54 per cent. The loss was lowest in steamed Mg 161 (7.04 per cent) but the raffinose content was significantly lower than that present in unprocessed Mg 161. All processing and cooking methods other than T_3 or T_6 have significant variation in their ability to reduce raffinose.

Results of the study further indicated that steaming of germinated sample was most effective in reducing raffinose content in Kanakamany and Mg 161. Germination was found to better than soaking in reducing raffinose and heat treatment further reduced the raffinose content. Among the various cooking methods pressure cooking was most effective in reducing raffinose content and this may be because of the high temperature used in pressure cooking. Soaking for 12 hours was also found to reduce raffinose content in pulses. Boiling was more effective than steaming for soaked pulses. This may probably be due to the leaching of solids in water used as cooking media. As revealed from the results soaking before boiling and steaming was better than boiling or steaming of unsoaked pulses. For unsoaked grains also, boiling was better than steaming in reducing the raffinose content, this may probably be due to the leaching loss. All processing and cooking methods were found to reduce raffinose content.

Variation in stachyose content during processing and cooking of Kanakamany and Mg 161 were assessed. Stachyose content of variety Kanakamany was 2.90 per cent. During processing and cooking methods it was reduced to 2.40 to 1.43 per cent. Loss in stachyose was maximum in germinated and steamed sample (T_8) where the reduction was 50.69 per cent, and the stachyose content was significantly lower than in all other processing and cooking methods. There was no significant variation in stachyose content during various processing and cooking methods like germination (T_7), soaking and boiling (T_3) and pressure cooking (T_5) where the reduction was 40.43 per cent (T_7), 35.35 per cent (T_3) and 35.52 per cent (T_5). Reduction in stachyose content was lowest for steamed Kanakamany (17.20 per cent) but stachyose content was significantly lower than in unprocessed Kanakamany. Stachyose content of steamed Kanakamany was on par with the stachyose content of boiled (T_2) and soaked and steamed (T_6) Kanakamany. Loss in

Table 28 Influence of processing and cooking on the oligosaccharides in Kanakamany and Mg 161

Processing and cooking methods	Raffinose g Kanakamany	per cent Mg 161	Stachyose g Kanakamany	per cent Mg 161	Verbascose g Kanakamany	per cent Mg 161
1. Unprocessed	00.48	00.71	02.90	01.77	03.80	03.47
2. Boiling	00.36 (25.00)	00.62 (12.68)	02.27 (21.72)	01.23 (30.11)	03.07 (19.21)	03.00 (13.54)
3. Soaking and boiling	00.29 (39.58)	00.55 (22.54)	01.87 (41.48)	01.03 (41.48)	02.13 (43.95)	02.43 (29.97)
4. Steaming	00.39 (18.75)	00.66 (07.04)	00.40 (17.20)	01.33 (24.43)	02.70 (28.95)	03.13 (09.80)
5. Pressure cooking	00.26 (31.25)	00.51 (18.31)	01.87 (25.17)	00.97 (35.79)	02.47 (36.84)	02.20 (20.17)
6. Soaking and steaming	00.33 (31.25)	00.58 (18.31)	02.17 (25.17)	01.13 (35.79)	02.40 (36.84)	02.77 (20.17)
7. Germination	00.23 (52.08)	00.46 (35.21)	01.73 (40.34)	00.93 (47.16)	01.90 (50.00)	01.93 (44.38)
8. Germination	00.20 (58.33)	00.38 (46.48)	01.43 (50.69)	00.86 (51.14)	01.57 (58.68)	01.67 (51.87)
F	65.88**	87.28**	23.62**	53.95**	50.37**	84.82**
SE	00.0115	00.0116	00.0935	00.0400	00.0986	00.067
CD	00.0155	00.0347	00.280	00.11	99 00.296	00.203

Kanakamany Raffinose	T_1	T_4	T_2	T_6	T_3	T_5	T_7	T_8
Mg 161	T_1	T_4	T_2	T_6	T_3	T_5	T_7	T_8
Kanakamany Raffinose	T_1	T_4	T_2	T_6	T_3	T_5	T_7	T_8
Mg 161	T_1	T_4	T_2	T_6	T_3	T_5	T_7	T_8
Kanakamany Verbascose	T_1	T_2	T_4	T_5	T_6	T_3	T_7	T_8
Mg 161	T_1	T_4	T_2	T_6	T_3	T_5	T_7	T_8

** Significant at 5 per cent level

stachyose content was 17.20 per cent in steamed samples (T_4), 21.72 per cent in boiled samples (T_2) and 25.17 per cent in samples processed by soaking and steaming (T_6).

In Mg 161 variety, stachyose content was 1.77 per cent, which was reduced to 01.13 to 00.86 per cent. Loss in stachyose content was minimum in samples which under go germination and steaming (T_8 - 51.44 per cent). Stachyose content of germinated and steamed Mg 161 (T_8) was on par with germinated (T_7) and pressure cooked (T_5) Mg 161. Loss in stachyose was 35.79 per cent in T_7 and 44.89 per cent in T_5. Stachyose content of germinated (T_7) and pressure cooked (T_5) Mg 161 was comparable with that of soaked and boiled (T_3) Mg 161. The loss in stachyose was 41.48 per cent for T_3 (Soaking and boiling). Stachyose content of T_3 was on par with soaked and steamed Mg 161 (T_6) where the loss in stachyose was 35.79 per cent. Soaked and Steamed samples (T_6) were comparable with boiled Mg 161 in stachyose content and the loss during boiling was 30.11 per cent. Minimum loss (24.43 per cent) in stachyose content was found in steamed sample (T_4) and the content was comparable with boiled Mg 161, but it was significantly lower than unprocessed Mg 161 (T_1). Results revealed that significant reduction in stachyose content occurred during processing and cooking treatments even though the difference in stachyose content among various processing and cooking methods were comparable.

As in the case of raffinose, germination and steaming (T_8) was the most effective processing and cooking treatment to reduce stachyose content in Kanakamany and Mg 161 followed by germination. Germination reduced stachyose content significantly which was further reduced by heat processing (steaming). Pressure cooking was better than boiling and steaming of soaked grains in reducing stachyose content. Boiling of soaked pulse (T_3) was more helpful than steaming of soaked pulse (T_6) in reducing the stachyose content. Boiling was better than steaming in decreasing the stachyose content. For both soaked and unsoaked grains higher percentage loss in stachyose content occurred during boiling than steaming. This may probably be due to the leaching of stachyose in the water used for boiling.

Processing and cooking methods found to reduce verbascose content in pulses. Verbascose content of Kanakamany was 3.80 per cent and on processing and cooking it was reduced from 3.07 to 1.57 per cent and the loss was from 58.68 to 19.21 per cent. Maximum loss in verbascose content was found in the samples treated by germination and steaming (T_8 - 58.68 per cent) and the verbascose content in these was significantly lower than in the samples processed or cooked by other methods. Germination resulted in 50 per cent loss in verbascose content which was on par with the verbascose content of soaked and boiled (T_3) Kanakamany. The loss during soaking and boiling (T_3) was 43.95 per cent while by soaking and steaming (T_6) it was reduced by 36.84 per cent. However, loss in verbascose content in T_3 and T_6 were comparable. Verbascose content of soaked and steamed (T_6) Kanakamany was comparable with pressure cooked (T_5) and steamed (T_4) samples. Also loss in verbascose content during pressure cooking (T_5) was found to be 35 per cent and due to steaming (T_4) the loss became 28.95 per cent. Loss in verbascose content was minimum during boiling (T_2) and the loss was only 19.21 per cent. Eventhough the verbascose content of boiled Kanakamany was significantly higher than other treatments it was significantly lower than unprocessed Kanakamany (T_1).

Verbascose content in Mg 161 was 3.47 per cent which was reduced from 3.13 to 1.67 per cent due to various processing and cooking methods. There was significant variation among different processing and cooking methods in the ability to reduce verbascose content of Mg 161. Loss in verbascose content was maximum in germination and steaming (51.87 per cent) followed by germination (44.38 per cent). Pressure cooking (T_5), soaking and boiling (T_3) and soaking and steaming (T_6) were found to reduce verbascose content by 36.60 per cent (T_5), 29.97 per cent (T_3) and 20.17 per cent (T_6). Loss in verbascose content was minimum in steaming (T_4 - 9.80 per cent) followed by boiling (T_2 - 13.54 per cent), but the verbascose content of these samples were significantly lower than that of unprocessed Mg 161.

Among the various processing and cooking methods studied germination and steaming method was the most effective in reducing the verbascose content of Kanakamany and Mg 161 followed by germination (T_7). Boiling of soaked grains was more effective than

steaming of soaked grains in reducing verbascose content. Pressure cooking comes next in reducing the verbascose content in Kanakamany, where as in the case of Mg 161 pressure cooking was more effective than heat treatment of soaked grain in reducing verbascose content. Steaming was better than boiling in reducing verbascose content in Kanakamany and this may be because high temperature processing was more effective in reducing verbascose content than boiling where the loss may be due to leaching. But in Mg 161 boiling was better than steaming in reducing verbascose content.

Oligosaccharide content of legumes were reduced during cooking (Price et al. 1988) and soaking and processing (Ogun et al. 1989). Richard and Esther (1992) reported significant loss in raffinose and stachyose during soaking, cooking and enzyme treatment of Kanakamany.

The mechanism by which the oligosaccharides were eliminated are not clear. Although leaching has been suggested by Price et al., (1988), the results of the work done by Richard and Esther (1992) and Silva and Braga (1982) suggests that leaching cannot be only factor. It was also reported that the rate of decrease was not commensurate with the duration of soaking.

Cooking brought about a greater reduction in the level of oligosaccharides compared with soaking eventhough the level of reduction was not proportional to the duration of cooking (Richard and Esther, 1993). Onigbinde and Akinyele (1983) also reported a decrease in the stachyose and raffinose content in Kanakamany. However, Rao and Belavady (1978) had reported an increase in the level of oligosaccharides after cooking.

The raffinose family of oligosaccharides, raffinose, stachyose and verbascose are reported to be a source of energy for germination (Aman, 1979) resulting in their reduction.

Metroglyph and index score method (Tables 29 and 30).

Metroglyph and index score method was administered to study the influence of various processing and cooking methods on the nutritional and antinutritional constituents in Kanakamany and Mg 161. Effect of various treatments on the major nutrients like protein, calcium and iron and the antinutritional constituents were assessed. Stachyose and verbascose were used on the X axis and Y axis respectively and each treatment is represented by a glyph in the graph (Fig 7 and fig 8). Various nutrients and antinutrients were represented by rays on the glyph and the rays for the same parameter have the same position on each glyph. Mean value and the index score for each parameter is given in the Tables 29 and 30. Length of the ray is in proportion to the score. The highest total index score indicates the best processing and cooking method to improve the nutritional quality and to reduce the antinutritional factors.

As revealed from the Table germination and steaming with a total score of 25, was the best method for cooking Kanakamany followed by soaking and boiling (21), germination (21), soaking and steaming (20) pressure cooking (19) and boiling and steaming (15).

In the case of Mg 161 pressure cooking (24) was the best method followed by germination and steaming (21), germination (21), soaking and boiling (21), steaming (16), soaking and steaming (15) and boiling (13).

Germination prior to steaming was the best method for Kanakamany where as pressure cooking was best for Mg 161. Lower score for pressure cooking in Kanakamany may be due to the higher loss of nutrients during pressure cooking when compared with Mg 161. Higher score for germination prior to steaming was due to the increased loss of antinutrients such as tannin and phytin in Kanakamany than in Mg 161.

Table 29 Mean values scores for different parameters of processed and cooked Kanakamany

	Dry green T_1	Boiling T_2	Soaking & boiling T_3	Steaming T_4	Pressure cooking T_5	Soaking & steaming T_6	Germinatioin T_7	Germinatiion & steaming T_8
Protein g per cent	24.06 (2)	23.19 (1)	21.17 (1)	24.69 (3)	23.86 (1)	23.04 (1)	27.52 (3)	25.11 (3)
Calcium mg per cent	223.67 (3)	126.67 (1)	141.00 (1)	131.67 (1)	112.67 (1)	182.33 (3)	191.33 (3)	204.33 (3)
Iron mg per cent	12.30 (3)	08.77 (1)	08.50 (1)	09.73 (3)	09.50 (2)	08.87 (1)	09.07 (1)	08.70 (1)
Tannin mg per cent	538.33 (1)	322.67 (3)	286.00 (3)	386.67 (1)	424.67 (1)	361.67 (3)	399.33 (1)	312.00 (3)
Phytin mg per cent	387.33 (1)	286.33 (3)	251.00 (3)	319.00 (1)	265.33 (3)	276.00 (3)	302.67 (1)	292.67 (3)
Trypsin Inhibitor TIU/mg	38.48 (1)	09.67 (3)	04.06 (3)	13.17 (3)	12.76 (3)	12.96 (3)	14.07 (3)	10.72 (3)
Raffinose g per cent	00.48 (1)	00.36 (1)	00.29 (3)	00.39 (1)	00.26 (3)	00.33 (1)	00.23 (3)	00.20 (3)
Stachyose g per cent	02.90 (1)	02.27 (1)	01.87 (3)	02.40 (1)	01.87 (3)	02.17 (2)	01.73 (3)	01.43 (3)
Verbascose g per cent	03.80 (1)	03.07 (1)	02.13 (3)	02.70 (1)	02.47 (2)	02.40 (3)	01.90 (3)	01.57 (3)
Total	14	15	21	15	19	20	21	25
Ranking	R_8	R_6	R_2	R_6	R_5	R_4	R_2	R_1

Figures in parenthesis indicate scores

Fig 7 Metroglyph indicating the effect of processing and cooking on the quality parameters of Kanakamany.

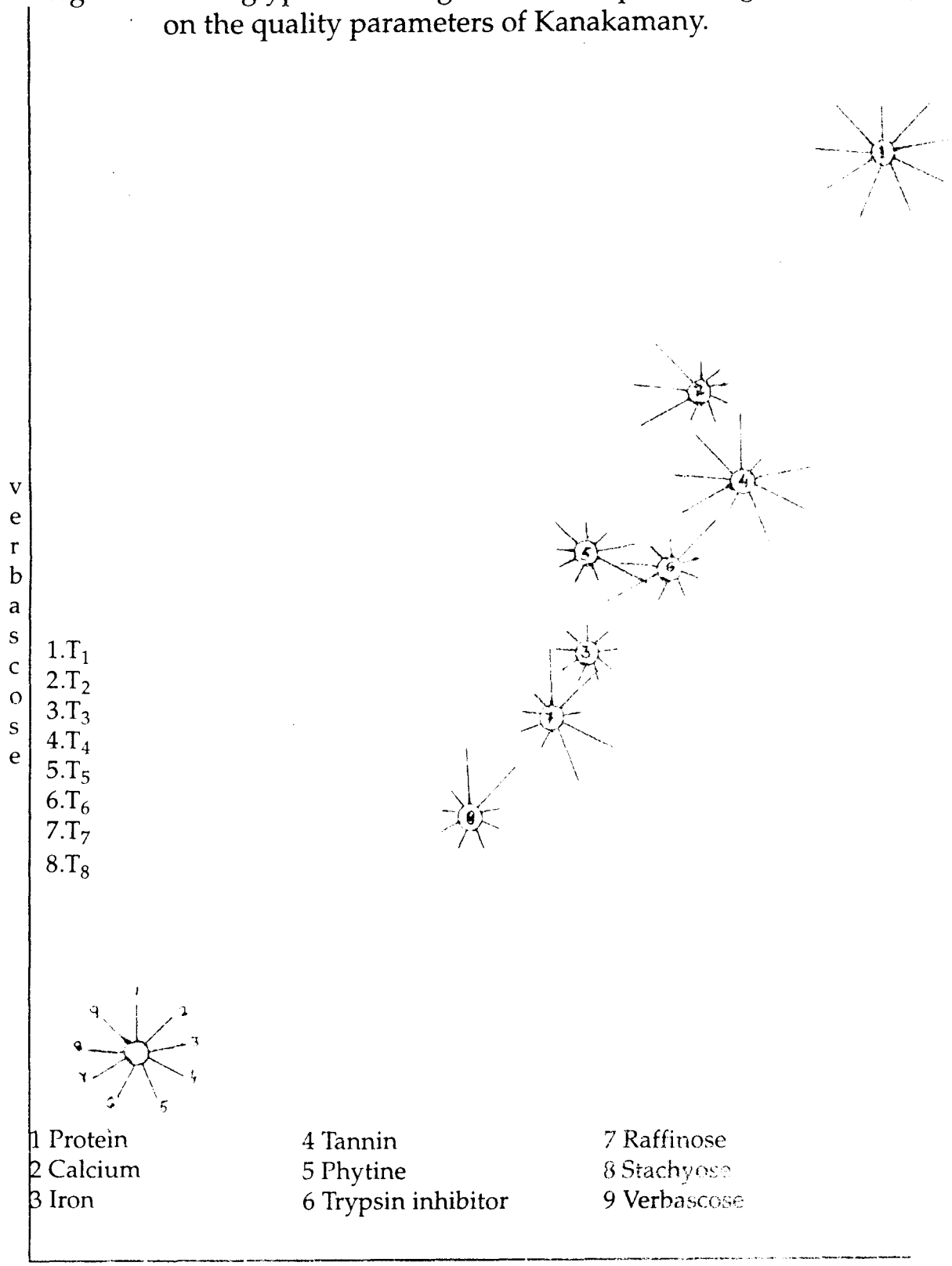
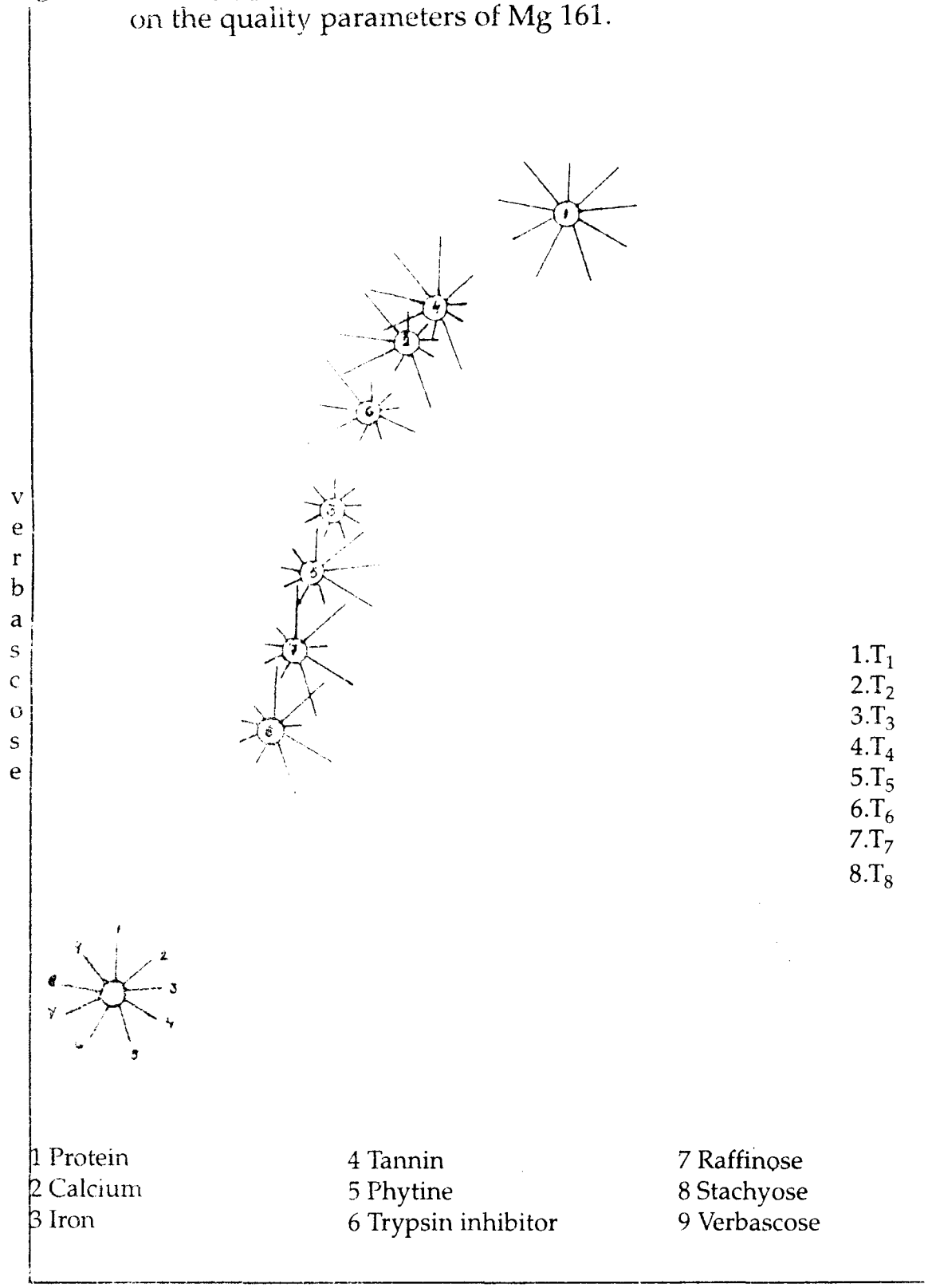


Table 30 Mean values for different parameters of processed and cooked Mg 161

	Dry grain T_1	Boiling T_2	Soaking & boiling T_3	Steaming T_4	Pressure cooking T_5	Soaking & steaming T_6	Germination T_7	Germination & steaming T_8
Protein g per cent	21.86 (2)	24.49 (2)	21.02 (1)	22.34 (3)	21.78 (2)	21.42 (1)	23.47 (3)	23.11 (3)
Calcium mg per cent	261.37 (3)	203.67 (1)	224.67 (1)	238.33 (2)	242.67 (3)	230.33 (1)	241.00 (3)	244.33 (3)
Iron mg per cent	12.63 (3)	08.67 (1)	08.83 (1)	09.10 (1)	10.10 (3)	09.33 (1)	09.50 (1)	08.90 (1)
Tannin mg per cent	316.6 (1)	7248.00 (3)	212.00 (3)	259.00 (3)	287.00 (1)	275.00 (2)	298.00 (1)	293.67 (1)
Phytin mg per cent	209.67 (1)	180.00 (1)	139.00 (3)	194.67 (1)	151.33 (3)	123.33 (3)	179.00 (1)	172.33 (1)
Trypsin Inhibitor TIU/mg	55.74 (1)	05.34 (3)	04.09 (3)	07.37 (3)	06.70 (3)	07.18 (3)	11.33 (3)	04.88 (3)
Raffinose g per cent	00.71 (1)	00.62 (1)	00.55 (3)	00.66 (1)	00.51 (3)	00.58 (1)	00.46 (3)	00.38 (3)
Stachyose g per cent	01.77 (1)	01.23 (1)	01.03 (3)	01.33 (1)	00.97 (3)	01.13 (2)	00.93 (3)	00.86 (3)
Verbascose g per cent	03.47 (1)	03.00 (1)	02.43 (3)	03.13 (1)	02.20 (3)	02.77 (1)	01.93 (3)	01.67 (3)
Total	14	13	21	16	24	15	21	21
Ranking	R_7	R_8	R_2	R_5	R_1	R_6	R_2	R_2

Figures in parenthesis indicate scores.

Fig 8 Metroglyph indicating the effect of processing and cooking on the quality parameters of Mg 161.



SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

A study was conducted to assess the quality of different varieties of cowpea and greengram. Five varieties each of cowpea viz, C 152, V 118, Pournami, Kozhinjipayar and Kanakamany and greengram varieties viz Mg 161, M 3 Co 2, Pusa 8793 and Pusa Baisakhi were selected to evaluate the physical, cooking, nutritional and antinutritional qualities. Physical characteristics like grain weight (12.45) and volume (11.33 ml) were maximum for Kanakamany where as length: width ratio was highest for pournami among cowpea varieties. In greengram M 3 recorded the highest length : width ratio (1.38) and volume (2.83 ml) and weight (3.18 g) were highest for pusa 8793.

Cooking qualities were assessed based on cooking time, swelling index, water uptake,solid dispersion, elongation ratio and elongation index. Lowest cooking time (47.00 minutes) obtained for Kanakamany and maximum swelling index (117.67 per cent) and water uptake (104.00 per cent) were for Pournami. Among greengram varieties cooking time was lowest for M 3 (31.33 minutes) and Mg 161 obtained lowest leaching loss (32.33 per cent). Maximum volume expansion (133.33 per cent) and water uptake (118.00 per cent) were obtained for Co 2. Elongation ratio (2.60 per cent) and elongation index (1.05) were highest in Pusa Baisakhi. Based on physical and cooking qualities Kanakamany in cowpea and Pusa 8793, M 3 and Mg 161 in greengram were found to be better.

Nutritional quality of different varieties were assessed by estimating the concentration of various nutrients. Among cowpea varieties, protein (24.06 g) and iron (12.30 mg) content were highest in Kanakamany, and the highest concentration of calcium (238.33 mg) was obtained for C 152. In greengram varieties Pusa 8793, M 3 and Mg 161 obtained highest concentration of protein (22.13 g), calcium (277.33 mg) and iron (12.63 mg) respectively. Based on these major quality parameters Kanakamany in cowpea and Pusa 8793, Mg 161 and M 3 in greengram were found to be better. In cowpea varieties tannin, (180.00 per cent) phytin (328.67 per cent) and trypsin inhibitor (29.26) TIU/mg were lowest in V 118 whereas raffinose (0.42) was lowest in C 152 and stachyose (2.00 per cent) and verbascose

(3.00 per cent in Kozhinjipayar. In the case of greengram tannin (310 per cent), and verbascose (3.10 per cent) were lowest in M 3. Co 2 contained the minimum concentration of phytin (201.33 per cent) and stachyose (0.95 per cent). Trypsin inhibitor (55.74 TIU/mg) and raffinose (0.407 per cent) were lowest in Mg 161 and Pusa 8793 respectively.

More than the quantity, the protein quality is important and the quality of protein in cowpea and greengram were decided by the concentration of limiting amino acid and the utilisation of proteins. Limiting amino acids methionine (92.33 mg/gN) and cystine (81.33 mg/gN) were highest in Kanakamany and Kozhinjipayar respectively in the case of cowpea varieties. Among greengram varieties, Mg 161 contained the maximum concentration of methionine (75.67 mg/gN) and cystine (58.33 mg/gN).

Animal experiments revealed that varieties with high protein content was not highest in quality parameters. Among cowpea varieties PER and NPU were highest for Pournami (1.92 per cent) and V 118 (86.13 per cent) respectively. In the case of greengram varieties PER was maximum for Mg 161 (2.83 per cent) where as NPU was highest in Pusa Baisakhi (84.27).

To assess the hypocholesterolemic effect of pulses Kanakamany with the optimum lysine arginine ratio of "1" was used., Incorporation of Kanakamany in high fat high cholesterol diet decreased the lipid level in liver and serum of the experimental animals indicating the hypocholesterolemic effect of Kanakamany.

Kanakamany and Mg 161 with better nutritional composition were selected. Various processing and cooking methods studied were boiling, soaking and boiling, steaming, pressure cooking, soaking and steaming, germination and germination and steaming. There was significant variation in cooking qualities among different varieties of cowpea and greengram in cooking time, water uptake and volume expansion.

Various processing and cooking methods were found to alter the nutritional and antinutritional constituents in pulses. Protein content increased during germination, germination prior to steaming and steaming. Minerals and antinutrients were found to

decrease during various processing and cooking methods. Maximum retention of calcium and iron occurred during germination prior to steaming, and pressure cooking respectively. Among the various processing and cooking methods soaking and boiling caused maximum reduction in tannin, phytin and trypsin inhibitor. While germination and steaming was found to be the most effective method in reducing the flatus producing oligosaccharides viz; raffinose, stachyose and verbascose in Kanakamany and Mg 161.

The investigations carried out in the study revealed that there was significant varietal variation in physical characteristics, cooking qualities, nutritional composition and antinutritional constituents in cowpea as well as in greengram. Biological qualities of the protein with reference to amino acid content, protein efficiency ratio and digestibility were also found to be varying with variety. Identification of Kanakamany and Mg 161 as better varieties than other varieties have paved the way for further indepth studies on these pulses.

REFERENCES

REFERENCES

Abdul Khaleque., Luiz, G., Elias. J., Edgar Braham and Ricardo Bressani (1985). Studies on the development of infant foods from plant protein sources. Part 1. Effect of germination of chickpea (*Cicer arietinum*) on the nutritive value and digestibility of proteins. *JUNIO*, **xxxv** (2) : 315-325.

Adams, M.W., and Bedford, C.L. (1973). Breeding food legumes for improved processing and consumer acceptance properties. In : *Nutritional improvement of food legumes by breeding*. ed. Milner, M. Protein Advisory Group, United Nations, Newyork. pp 299-304.

Agbo, N. G. (1982). Genetic, Physico-chemical and structural parameters affecting texture of dry edible beans. *Ph.D. Thesis*, Michigan State University, East Lansing, MI.

Ahmad, S.U., Chaudhry, F.H. and Chaudhry, M. (1975). Effect of cooking on the essential amino acid content and NPU of common pulses. *Pakistan Journal of Science and Industrial Research*, **18** (3-4) : 175-178.

Akingele, I.O., Onigbinde, A.C., Hussain, M.A. and Dmololu, A. (1986). Physicochemical characteristics of 18 cultivars of Nigerian cowpea (*V unguiculata*) and their cooking properties. *Journal of Food Science*, **51** : 1483-1485.

Albersheim, P. and Darvill, A.G. (1985). Oligosaccharides *Sci. Am.* September : 44-49.

Ali, H.I. and Harland, B.F. (1991). Effect of fiber and phytate in sorghum flour on iron and zinc in weanling rats: A Pilot Study. *Cereal Chemistry*, **68** : 37-41.

Alka Sharma and Salil Sehqual (1992). Chemical composition and physico chemical properties of Fababean. *Legume Research*, **15** (3) : 125-128.

Aman, P. (1979). Carbohydrate in raw and germinated seeds from mungbean and chickpea *Journal of Food and Agriculture*, **30** : 869-875.

Anderson, J.W., Story, L., Sieling, B., Chen, W.J. L., Petro, M.S. and Story. J. (1984). Hypocholesterolaemic effect of oat bran or bean intake for hypercholesterolaemic men. *American Journal of Clinical Nutrition*, **40** : 1146-1155.

Arti Duhan., Bhag Mal Chauhan., Darshan Punia and Amin Chand Kapoor (1989). Phytic acid content of chickpea (*Cicer arietinum*) and blackgram (*Vigna mungo*). Varietal differences and effect of domestic processing and cooking methods. *Journal of the Science of Food and Agriculture*, **49** : 449-445.

Attia, R.S., EI-Tabey Shehata, A.M., Amar, M.E. and Hamza, M.A. (1994). Effects of cooking and decortication on the physical properties, the chemical composition and the nutritive value of chickpea. *Food Science and Technology Abstract*, **26** (7) : 135.

Autunes, P.L. and Sgarbieri, V.C. (1979). Influence of time and condition of storage on technological and nutritional properties of a dry bean (*Phaseolus vulgaris, L.*) variety Rosinha G2. *Journal of Food Science*, **44** : 1703-1706.

'Ayoma, K., Nakamishi M. and Ashinda K. (1973). *Journal of Nutrition* **103**: 54.

Bakr, A.A. and Gawish, R.A. (1992). Nutritional and cooking quality evaluation of dry cowpea (*Vigna sinensis L*) grown under different agricultural conditions. 11. Effect of soaking and cooking processes on the physical, nutritional and sensory characteristics of cooked seeds. *Journal of Food Science and Technology* **29** (6) : 375-380.

Barroga, C.F., Laurena, A.C. and Mendoza C.M.T. (1985). Polyphenols in mungbeans (*Vigna radiata*) Determination and removal - *Journal of Agriculture and Food Chemis try* 33: 1006-1009.

Barroga, C.F., Laurena. C.A. and Mendoza E.M.T. (1985). Effect of condensed tannins on the *invitro* protein digestibility of many beans (*Vigna radiata L Wilezek*) *Journal of Agriculture and Food Chemistry* **33**(6) : 1157-1159.

Bassiri, A. and Nahapetian, A. (1977). Differences in concentrations and interrelationships of phytate, phosphorus, magnesium, calcium, zinc and iron in wheat varieties grown under dry land and irrigated conditions. *Journal of Agriculture and Food Chemistry* **25**: 1118 - 1122.

Batra V.I.P. and Dhindsa, K.S.(1989). Changes in oligosaccharides of lentil on cooking and germination. *The Indian Journal of Nutrition and Dietetics* **26**: 75- 83.

Beal, L. and Mehta, T. (1985). Zinc and Phytate distribution in peas. Influence of heat treatment, pH, substrate and phosphorus on pea phytate andphytase. *Journal of Food Science*, **50** (3): 96-100.

Belavady, B. and Banerjee, S. (1983). Effect of germination on the phosphorus value of Indian pulses. *Food Research*. **18** : 226 - 228.

Bhatty, R.S. (1982). Albumin proteins of eight edible grain legume species: electrophoretic patterns and amino acid composition. *Journal of Agriculture and Food Chemistry* **30**: 620.

Bhatty, R.S. (1984). Relationship between physical and chemical characteristics and cooking quality of lentil. *Journal of Agriculture and Food Chemistry*, **32** (5): 1161 - 1166.

Bhatty, R.S. (1988). Composition and quality of lentil (*Len culinaris medik*) : A review. *Canadian Institute of Food Science and Technology*, **21** (2) :144- 160.

'Bhattacharya, K.R., Sowbhagya C.M. and Indudharaswamy Y.M. (1972). *Journal of the Science of Food and Agriculture* **23** : 173.

Bingwen, L., Zhaofeng, W., Wanzhen, L. and Rongjue, Z. (1981). Effect of bean meal on serum cholesterol and triglycerides. *Chinese Medical Journal* **94**: 445 - 458.

Bishnoi, S., Khetarpaul, N. and R.K. Yadav (1993). Effect of domestic processing and cooking methods on phytic acid and polyphenol contents of pea cultivars (*Pisum sativum*) *Plant Foods for Human Nutrition* **45**: 384 - 388.

Blis, F.A. and Hall, T.C. (1977). Food Legumes: compositional and nutritional changes induced by breeding. *Cereal Foods World* **22** (3) : 106.

Borade, V.P., Kadam, S.S. and Salukhe, D.K. (1984). Changes in phytate phosphorus and minerals during germination and cooking of horsegram and mothbean. *Qualitas Plantorum plant Foods for Human Nutrition*. **34** (2) 151 -157.

Bressani, R. (1975). Legumes in human diets and how they might be improved. In: Milner, M (ed), *Nutritional Improvement of Food Legumes by Breeding*. New York; John Wiley and sons pp 15-42.

Bressani, R. (1985). Nutritive value of cowpea. In: *Cowpea Research, Production and Utilization*. S.R. Singh and K.O. Rachie, eds. John wiley and sons:New York.

Bressani, R. (1988). The nutritive value and potential uses of the grains and by products. *Food and Nutrition Bulletin* **10** (2): 49-59.

Bressani, R. and Elias, C.L. (1974). Legume Foods, *In New Protein Foods*. (1) : 230, Pub. Academic Press.

Bressani, R. and Elias, L.G. (1980). The nutritional role of polyphenols in beans. In : *Polyphenols in cereals and Legumes*, ed. Hulse L.H., International ·Development Research Center, Ottawa, pp. 61-68.

Bressani,R., and Elias, L.G. (1988). Nutritional value of legume crops for humans and animals. In summer field. R.J. and Bunting, A.H. (eds) *Advances in Legume Science*, Proceedings of the International legume conference, Vol 1, Royal Botanic Gardens, Kew, pp 135 - 155.

Bressani, R., Elias, L.G. and Braham, J.E. (1982). Reduction of digestibility of legume proteins by tannins. *Journal of Plant Foods* **4**: 43 - 55.

Bressani, R., Hernandez, E. and Braham. J.E. (1988). Relationship between content and intake of bean polyphenolics and protein digestibility. *Plant Foods for Human Nutrition* **38**: 5 - 22.

Burns, R.A. (1987). Protease inhibitors in processed plant foods. *Journal of Food Prot* **50** 161 - 166.

'Carr - Drekker (1956). Clinical Chemistry. 2 : 353.

Carroll, K.K. (1978). The role of dietary protein in hypercholesterolemia and atherosclerosis. *Lipids* 13, 360-365.

Castillo, E.M., De Lumen, B.O., Reyes, P.S. and De Lumen, H.Z. (1990). Raffinose Synthase and galactinol synthase in developing seeds and leaves of legumes. *Journal of Agriculture and Food Chemistry* **38**: 351 - 355.

Cerning, J., Saposnik, A. and Guilbot, A. (1975). Carbohydrate composition of horsebean (*Vicia faba*) of different origins *Cereal Chemistry* **52**: 125 - 138.

Chandrasekharan U. and Jayalekshmi, K. (1978). Evaluation of protein quality of sprouted, roasted and autoclaved legumes on albino rats. *Indian Journal of Nutrition and Dietetics;* **15** : 414-421.

Chang, M.J., Colins, J.L., Bailey, J.W. and coffey, D.L. (1994). Cowpea tannins related to cultivars, maturity, dehulling and heating. *Journal of Food Science*, **59**, (5): 1034.

Chang, S.Y., Morr, C.V. and Jen. J.J. (1981). Effect of Microwave and conventional cooking on the nutritive value of colossus pea (*Vigna unguiculata*) *Journal of Food Science* **46**: 272.

Chang, K.C. and Satterlee, L.O. (1982). Chemistry of dry bean protein. *Journal of Food Processing and Preservation* **6**: 203.

Chavan,S.P., Dhage, A.R. Munjal, S.V., Kale, A.A., Desai, B.B. and Aber, R.P. (1994). Influence of irrigation on nutritional composition of some chick pea (*cicer-arietinum L.*) cultivars. *Legume Research* **17** (2) : 83 - 89.

Chavan, J.K., Kadam, S.S. and Salunkhe, D.K. (1986). Biochemistry and technology of chick pea (*cicer arietinum L*) seeds. *CRS Critical Review of Food Science and Nutrition*; **25**: 107 - 123.

Chavan, S.P., Dhage, A.R., Munjal, S.V., Kale, A. A., Desai, B.B. and Aher, R.P. (1994). Influence of irrigation on nutritional composition of some chick pea (*cicer-arietinum L.*) cultivars. *Legume Research*, 17 (2) : 83-89.

Chavan, J.K., Shere, D.M., Jawale, H.K. and Salunkhe, D.K. (1983). Effect of Soak treatment to legume seeds on the cooking quality of resultant dhal. *Indian Journal of Nutrition and Dietetics* **20** (8): 249 - 254.

Cheryan, M. (1980). Phytic acid interactions in food system *CRC Critical Review Food Science and Nutrition*. **13**: 297-335.

Chitra,U., Vimala, V., Singh, U. and Geervani, (1995). Variability in phytic acid content and protein digestibility of grain legumes. *Plant Food for Human Nutrition* **47** (1): 167 - 172.

Cittadini, D., Pietropaolo, C., De Cristoaro, D and D' Ayjello Catacciole, M. (1964). *In vivo* effect of L. Lysine on rat liver arginise *Nature* **203** 613 - 643.

COMA, (Committee on Medical Aspects of Food Policy) (1984). *Report of the panel on diet in relation to cardiovascular disease: Report on Social Subjects* **28**. London: HMSO

Conoor, S.L., Gustafson, J.R., Artaud Wild, S.M., Flavell, D.P., Classick - Kohn, C.J., Hatcher, L.F. and Conoor W.E. (1986). The cholesterol / saturated fat index; an indication of the hypocholesterolaemic and atherogenic potential of food. *Lancet*, 1229 - 1232.

Cown, J.W., Esfahani, M., Salji, J.P. and Nahapetian, A. (1987). Nutritive value of middle Eastern Foods. III Physiological availability of iron in selected foods common to the middle east. *Journal of the Science of Food and Agricul ture.* **18**: 227-228.

Cristofaro, E., Mottu, F. and Wubrmann, J.J. (1974). Involvement of the raffinose family of Oligosaccharides in flatulence, in sugars. In : *Nutrition*, H.L. Sipple and K.W. Mc Nutt. Eds. Academic Press, London 313.

David Kritchevsky (1987). Cholesterol lowering agents. *Trends in Atheroselerosis Research.* Biochemistry Department of Kerala University. 107-116.

Davies, N.T. and Nightingale, R. (1975). The effect of phytate on intestinal absorption and secretion of zinc and whole body retention of Zinc, Copper, Iron and manganese in rats. *British Journal of Nutrition* **34**: 243.

'De Leon, L., Bressani, R., and Elias. L.G. (1989). Effect of seed coat on the hard to cook phenomen on of common bean (*Phaseolus vulgaris*) *Archivos Latinoamericanos de Nutrition* **39**. 405 - 407.

Demooy, B.E. and Demooy, C.J. (1990). Evaluation of cooking time and quality of seven diverse cowpea (*Vigna unguiculata (L.)* walp) varieties. *International Journal of Food Science and Technology;* **25** (2) : 209-212.

Deosthale, Y.G. (1982). Food processing and nutritive value of Legumes. In *Pulse Production* Eds. Srivastava, H.C; Bhaskaran, S; Menon, K.K. G; Ramanujam, S. and Rao M.V. Oxford and IBH Publishing Co, New Delhi: 377 - 389.

Deshpande.S.S., (1992). Food legumes in Human nutrition : A Personal perspective. *Critical Review in Food Science and Nutrition* **32** (4) 333 - 363.

Deshpande, S.S. and Cheryan, M. (1983). Changes in the phytic acid, tannins and trypsin inhibitor activity on soaking of dry beans (*P. vulgaris L.*) *Nutrition Report International* **27**: 371-378.

Deshpande, S.S. and Cheryan, M. (1984). Effect of phytic acid divalent cations and their interactions on alpha amylase activity. *Journal of Food Science* **49**: 516-519.

Deshpande, S.S. and Nielsen, S.S. (1987 a). *In vitro* enzymatic hydrolysis of phaseolin, the major storage protein of *Phaseolus vulgaris* L. *Journal of Food Science* **52**: 1326 - 1329.

Deshpande, S.S. and Nielsen, S.S. (1987 b). *In vitro* digestibility of dry beans. (*Phaseolus vulgaris L.*) proteins: the vole of heat stable protein inhibitors. *Journal of Food Science* **52**: 1330 - 1334.

Deshpande, S.S., Sathe, S.K. and Salunkhe, D.K. (1984). Interrelationship between certain physical and chemical properties of dry bean (*phaseolus vulgaris*). *Qual plant Plant Foods for Human Nutrition* **34** : 53-65.

Deshpande, S.S., Sathe, S.K., Salunkhe, D.K. and Cornforth, D.K. (1982). Effects of dehulling on phytic acid, polyphenols and enzyme inhibitors of dry beans (*Phaseolus vulgaris L*) *Journal of Food Science* **47**: 1846-1847.

Dhurandhan, N.V. and Chang, K.C. (1990). Effect of cooking on firmness, trypsin inhibitors, lectins and cystine / cysteine content of Navy and Red kidneybeans (*P. vulgaris*). *Journal of Food Science* **55** (3): 470 - 474.

Earp, C.F., Akingbala, J.O., Ring, S.H. and Rooney, L.W. (1981). Evaluation of several methods to determine tannins in sorghum with varying Kernel Characteristics *Cereal Chemistry* **58** : 234 - 238.

Edijala, J.K. (1980). Effects of processing on the thiamine, riboflavin and protein content of cowpeas (*Vigna unguiculatea* (L) walp). II Alkali (Potash) treatment. *Journal of Food Technology* **15**: 445 - 453.

Ejiofor, M.A.N. and Oti, E. (1987). Studies on the fermentation of seeds of the American oil bean tree (*Pentaclethra macrophylla) International Tree Crops Journal* **4**:135-144.

'Eklund, A. and Sjoblom, L. (1986). Effect of dietary protein on hepatic and plasma lipoprotein fraction during dietary induced hypercholesterolemia in male rats. *Biochemica et Biophysica Acta* **877**: 127 - 134.

Ekpenyong, T.E. (1985). Effect of cooking on polyphenolic content of some Nigerian legumes and cereals. *Nutritional Report International.* **31**: 561-565.

Elias, L.G., De Fernandez, D.G. and Bressani, R. (1979). Possible effects of seed coat polyphenolics on the nutritional quality of bean proteins. *Journal of Food Science;* **44**: 524-527.

'El Shimi, N.R., Damir, A.A. and Ragab, M. (1984). *Indian Journal of Medical Research* **4** :185-189.

Erskine, W., Williams, P.C. and Nakkocil, H. (1985). Genetic and environmental variation in the seed size, protein, yield and cooking quality of lentils. *Field Crops Research* **12**: 153-161.

Esteves, A.M., and Luh, B.S. (1985). Chemical and physical characteristics of ready - to - eat dry beans. *Journal of Food Science* **50** (3) : 777-781.

Evans R.J., and Bandemer, S.L. (1967). Nutritive Value of legume seed proteins. *Journal of Agriculture and Food Chemistry* **15**: 439 - 443.

Evans, R.J., Bauer, D.H., Adams, M.W. and Saettler, A.W. (1978). Methionine and Cystine contents of bean (*Phaseolus*) seeds. *Journal of Agriculture and Food Chemistry***26**: 1234-1237.

Evans, I.M. and Boulter, D. (1974). Chemical methods suitable for screening for protein content and quality in cowpea (*Vigna unguiculata*) meals. *Journal of the Science of Food and Agriculture* **25**: 311 - 322.

Fardiaz, D., and Markaris, P. (1981). Degradation of phytic acid, polyphenols and enzyme inhibitors of dry beans (*phaseolus vulgaris*) *Journal of Food Science* **47**: 1846 - 1850.

Fashakin, J.B. and Fasanya, J.I. (1988). Chemical composition and nutritive changes of ome improved varieties of cowpea (*Vigna unguiculata*) 1. Some selected varieties from the International Institute for Tropical Agriculture, Ibandan, Nigeria. *Tropical Science;* **28** ; (2) 111-118.

Ferguson, E.L., Gibson, R.S., Thompson, L.U., Ounpuu, S. and Berry, M. (1988). Phytate, zinc and calcium contents of 30 East African foods and their calculated phytate : Zn, Ca: phytate, and [ca] [phytate]/[zn] molar ratios. *Journal of Food Composition Analysis* **1**: 316-325.

Fernando, T. and Bean, G. (1987). Variation of the antinutritional tannic acid content among the cultivars of wingedbean (*Psophocarpus tetragonolobus LDC*) *Food Science and Technology Abstracts* **19** (12): 97.

Fordham, J.R., C.E. Wells, and L.H. Chen (1975). Sprouting seeds and nutrient composition of seeds and sprouts *Journal of Food Science;* **40**: 552-556.

Gabriel O. Farinu and Giovanni Inqraco (1991). Gross composition, amino acid, phytic acid and trace elements contents of thirteen cowpea cultivars and their nutritional significance *Journal of the Science of Food and Agriculture* **55** : 401- 410.

Garcia - Lopez, J.S., Erdman, J.W., Erdma, J.W., Jr. and Sherma, A.R. (1990). Iron retention by rats from casein legume test meals: effect of tannin level previous diet. *Journal of Nutrition.* 120:760.

Gaspen Ros and Jimmesh - Collins (1992). Physico chemical and nutritional properties of cowpea, heated under pressure. *Journal of the Science of food and Agriculture,* **58**: 369 - 374.

Gatehouse, A.M.R., Gatehouse J.A., Dobie, P., Kilminster, A.M. and Boulter. D. (1979). Biochemical basis of insect resistance in *Vigna unguiculata. Tropical Science* **6**: 68 - 73.

Geervani, P. and Theophilus F. (1980). Effect of home processing on the nutrient composition of certa in high yielding legume varieties. *The Indian Jou rnal of Nutrition and Dieteties.*, **17**: 443-446.

Geervani, P. and Theophilus, F. (1980). Effect of home processing on the protein quality of selected legumes. *Journal of Food Science*: **45** (3): 707-710.

George Grant, Patrician M., Dorward, Wendy, C., Buchan., Julica, C., Armour and Arpad Pusztai (1995). Consumption of diets containing raw soyabean (*Glycine-max*) kidneybean (*Phaseolus vulgaris*) cowpea (*Vignaunguiculata*) or lupin seeds (*Lupins angustifolius*) by rats for up to 700 days: effect on body composition and organ weights. *British Journal of Nutrition*. **73**: 17 - 29.

Gibney, M.J. (1982). Hypocholesterolaemic effect of soyabean proteins. *Procedings of the Nutrition society* **41**:19-26.

Gillooly, M., Bothwell, T.H., Charlton R.W., Torrance J.D., Bezwoda W.R., Mac Phail, A.P. and Derman D.P. (1984). Factors affecting the absorption of iron from cereals. *British Journal of Nutrition* **51**: 37 - 46.

Ginevra Lombardi., Boccia., Giuseppe Di Lullo and Emilia Carnovale (1991). *In vitro* iron dialysability from legumes; influence of phytate and extrusion cooking. *Journal of the science of Food and Agriculture* **55**: 599 -605.

Gupta, Y.P. (1983). Nutritive value of food legumes. In. *Chemistry and Biochemistry of Legumes*. ed. S.K. Arora, *Edward Arnold, London* pp. 287 - 327.

Gupta, V.P. (1987). Antinutritional and toxic factors in food legumes: a review *Plant Foods for human Nutrition* **37** 201 - 288.

Gupta, K. and Wagle, D. S. (1980). Changes in antinutritional factors during germination in *P. mungoreus* a cross between *P. Mungo* (M_1*-1) and P. aureus* (T_1) *Journal of Food Science* **45**: 394.

Habib, F.G. H., Riad, W.Y. and Morcos, S.R. (1989). Nutritional value of some pea grown in Egypt. *Bulletin of the Nutrition Institute of the Arab Republic of Egypt* **9** (1): 53-60.

Hageman, A.E., and Butler, L.G., (1991). Tannins and Lignins in Herbivores: Their interaction with secondary plant metabolites (1) : *Academic Press, NewYork*. 355.

Haider, F.G. (1981). Inactivation studies on trypsin inhibitory activity of redgram cultivars. *Nutrition Report International* **23**: 1167.

Hallberg, L., Rossander, L., and Skanberg, A.B. (1987). Phytate and the inhibitory effect of bran on iron absorption in man. *American Journal of Clinical Nutrition* **45**: 988 - 996.

Hamidullah Shah., Rooh Niaz and Nisar Mohammad. (1988). Biochemical and nutritional evaluation of some important varieties of pulses. *Sarhad Journal of Agriculture* **4** (6): 751 - 755.

Harland, B.F., Oke, O.L. and Felix - Phipps. R. (1988). Preliminary studies on the phytate content of Nigerian Foods. *Journal of Food Composition Analysis* **1**:202 -205.

Hashim, N. and Mohsan, L. (1986). Effect of boiling on the nutrient contents of legumes. *Food Science and Technology* Abstract. 18 (3) : 181.

Hawk and Oser (1965). In *Practical Physiological Chemistry* (ed) Tata MC graw Hill, Bombay. New Delhi.

Haytowitz, D.B. and Mathews, R.H.(1986). Composition of foods: legume and legume products, United States Department of Agriculture , *Agriculture Handbook* **9**:16.

Hazell, T. (1985). Minerals in foods: dietary sources, Chemical forms, interactions, bioavailability. *World Review of Nutrition and Dieteties* **46**: 1 - 123.

Henley, E.C. and Kuster, J.M. (1994). Protein quality evaluation by Protien Digestibility-corrected Amino Acid Scoring *Food Technology*, April 74 - 77.

Hernandez, T., Hernandez, A. and Martinez, C. (1991). Polyphenols in alfalfa leaf concentrates. *Journal of Agricultural Food Chemistry* **38**: 1120-1122.

Hicks, M.J. and Stanley, D.W.(1987). Hard-to cook defect in black beans: Soaking and cooking processes. *Journal of Agriculture and Food Chemistry*, **35** (4) : 576 -583.

Hsu,K.H.,Kim, C.J. and Wilson, L.A. (1983). Factors affecting water uptake of Soybeans during soaking. *Cereal Chemistry* **60** : 208-211.

Hsu, D.,H.K. Leung, P.L., Finney and M.M. Morad (1980). Effect of germination on nutritive value and baking properties of dry peas, lentils and faba beans. *Journal of Food Science*. **45**: 87-92.

Huff, M.W. and Carroll, K.K. (1980). Effects of dietary protein on turnover, oxidation, and absorption of cholesterol and on steroid excretion in rabbits. *Journal of Lipid Research* **21** : 546-558.

Idourame, A., Tinsley, A.M. and Weber, C.W. (1989). Nutritional quality and sensory acceptability of Okara prepared from germinated tepary beans. *Journal of Food Science* 54 : 114.

Iyer, V., Salunkhe, D.K., Sathe, S.K. and Rockland, L.B. (1980). Quick cooking beans (*Phaseolus vulgaris* L) II Phytate, oligosaccharides and antienzymes. *Plant Foods for Human Nutrition* 30:45.

Janardhanan, K. and Nalini, K. (1991). Studies on the tribal pulses Entada Scandens Benth: Chemical composition and antinutritional factors. *Journal of Food Science and Technology* **28** (4): 249-251.

Jenkins, D.J.A., Wolever, T.M.S., Taylor, R.H., Ghafari, H., Jenkins, A.L. Barker, H.M. and Jenkins, M.J.A. (1980). Rate of digestion of foods and post prandial glycaemia in normal and diabetic subjects. *British Medical Journal* **281**: 14-17.

Jenkins, D.J.A., Wong, G.S., Patten, R., Bird, J., Hall, M., Buckely, B.C., Mc. Guire, V., Reichert, R. and Little, J.A. (1983). Leguminous seeds in the dietary management of hyperlipidaemia. *American Journal of Clinical Nutrition* **38**: 567-573.

Jood, S., Chauhan, B.M. and Kapoor, A.C. (1987). Polyphenols in Chickpea and blackgram as affected by domestic processing and cooking methods. *Journal of the Science of Food and Agriculture* **38**:145-149.

Jood, S., Metha, U., Singh, R. and Bhat, C.M. (1985). Effect of processing on flatus producing factors in legumes *Journal of Agriculture and Food Chemistry* **33**: 268-271.

Jood, S., Mehta, U. and Singh, R. (1986). Effect of processing on available carbohydrates in legumes. *Journal of Agriculture and Food Chemistry* **34**: 417.

Kachare, D.P., Chavan. J.K. and Kadam, S.S. (1988). Nutritional quality of some improved cultivars of cowpea. *Plant Foods for Human Nutrition* **38**(2): 155-162.

Kailasapathy, K. and Koneshan, T. (1986). Soaking studies onthe seeds of five legumes commonly consumed in Srilanka. *Legume Research*, **9** (1): 55-60.

Kamlesh Saharan and Neelam Khetarpaul (1993). Biological utilization of vegetable peas: Effect of cooking and varietal differences. *Plant Foods for Human Nutrition*.**45** : 388-397.

Kan, T. and Shipe, W.F. (1984). Enzyme diafiltration technique for *invitro* determination of protein digestibility and availability of amino acids of legumes. *Journal of Food Science* **49** : 794.

Kanwall Birender., Soni, G.L. and Rattan Singh (1987). Nutritional evaluation of gram (*CicerArietinum*) Varieties *Human Nutrition : Food Science and Nutrition* **41**F : 121-128.

Kataria, A., Chauhan, B.M. and Punia, D. (1989). Antinutrients and protein digestibility (*invitro*) of mungbean as affected by domestic processing and cooking. *Food Chemistry* **32**: 9-17.

Kaul, M. and Bajwa, M. (1987). Effect of heat and natural fermentation on trypsin inhibitor and hemagglutinin of blackgram (*Phaseolus mungo*) *Journal of Nutrition and Dietetics* **24** :40-44.

Kaur, D. and Kapoor, A.C. (1990). Some antinutritional factors in rice bean (*Vigna umbellata*): effects of domestic processing and cooking methods. *Food Chemistry* **37**: 171-179.

Khan, M.A. and Ghafoor, A. (1978). The effect of soaking, germination and cooking on the protein quality of mash bean (*Phaseolus mungo*). *Journal of the Science of Food and Agriculture*. **29**: 461-464.

Khan, M.A., Jacobson, I. and Eggum, B.O. (1979). Nutritive value of some improved varieties of legumes. *Journal of the Science of Food and Agriculture*. **3** (4): 395-400.

Khokhar, S. (1984). Studies on nutrient composition and antinutritional factors of mothbean (*Vigna aconitifolia*). *M.Sc Thesis*; Haryana Agricultural University, Hisar, India.

Khokhar, S. and Chauhan, B.M. (1986). Antinutritional factors in mothbean (*Vigna aconitifolia*) varietal differences and effects of methods of domestic processing and cooking. *Journal of Food Science* **51**: 591.

Knuckles, B.E., Kuzmicky, D.D. and Betschart, A.A. (1985). Effect of phytate and partially hydrolyzed phytate on in vitro protein digestibility. *Journal of Food Science* **50**, 1080-1082.

Kochhar, N., Walker, A.F. and Pike, D.J. (1988). Effect of variety on protein content, amino acid composition and trypsin inhibitor activity of cowpea. *Food Chemistry*. **29**: 65-78.

Kochler, H.H., Herrick, H.E. and Burke, D.W. (1986). Differentiating the lectin activity in twenty four cultivars of dry beans *(P. vulgaris L.) Journal of Food Science*. 5 (6) : 1471 - 1475.

Kochler, H.H., Chang, C.H., Scheler, G. and Burke, D.W. (1987). Nutritional composition, protein quality and sensory properties of thirty six cultivars of dry beans *(Phaseolus vulgaris* L.) *Journal of Food Science*. **52** (5): 1335-1340.

Kon, S. and Sanshuck, W. (1981). Phytate content and its effect on cooking quality of beans. *Journal of Food Processing*. **5**: 169-178.

Kratzer, F.H. (1965). Soyabean protein mineral interrelationship. *Food Processing Ed. Am. Sci. Exper. Biol*. **24** : 1492.

Kritchevsky, D. (1979). Vegetable protein and atherosclerosis. *Journal of American Oil Chemists Society*. **56**: 135-140.

Kritchevsky, D., Tepper, S.A., Czarnecki, S.K. and Klurfeld, N.M. (1982). Atherogenicity of animal and vegetable protein: Influence of the lysine to arginine ratio. *Atherosclerosis*. **41**: 429-431.

Kritchevsky, D., Tepper, S.A., Czarneeks, S.K., Klurfeld, D.M . and Story, J.A. (1981). *Atherosclerosis* **39** : 169.

Krober, O.A., Jacob, M.K., Lal, R.K. and Kashkary, V.K. (1970). Effect of variety and location on the protein content of pulses. *Indian Journal of Agricultural Science*. **40**: 1025-1030.

Kumar K.G., Venkataraman, L.V., Jaya, T.V. and Krishnamurthy, K.S (1978). Cooking characteristics of some germinated legumes: changes in phytin, Ca^{++},Mg^{++} and pectins. *Journal of Food Science*. **43**: 85-89.

'Kurien, P.P., Desikachar, H.S.R. and Parpia, H.A.B (1972) *Tropical Agricultural Research Series* No: **6** : 226.

Kuyvenhoven, M.W., West, C.E., Vander Meer, R. and Beynen, A.C., (1986). Faecal steroid excretion in relation to the development of casein induced hypercholesterolemia in rabbits. *Journal of Nutrition* **116**, 1395-1404.

Kylen, A.M. and Mc Cready, R.M. (1975). Nutrients in seeds and sprouts of alfalfa, lentil, mungbean and soyabean. *Journal of Food Science* 40:1008

Lalitha, D., Hoch, G. and Kievernagel, Y. (1987). Influence of phytate on *invitro* digestibility of casein under physiological conditions. *Qual Plant Plant Foods for Human Nutrition* **37** (3): 229 - 236.

Liener, I. (1975). Antitryptic and other antinutritional factors in legumes. In Milner, M (ed) *Nutritional Improvement of Food Legumes by Breeding*, New York; JohnWiley and sons pp 43-48.

Liener, I.F. (1976). Legume toxins in relation to protein digestibility: A review; *Journal of Food Science* **41**: 1076-1081.

Liener, I.F. (1976). Nutritional value of Food Protein Products. In *Soyabeans Chemistry and Technology* (Vol 1 Proteins) 203-77.

Liener, I.E. (1980). *Advances in legume Science, by Summer field,* R. J. and Bunting, A.H. (Eds)Kew, Richmond , Surrey, U.K. Royal Botanical Gardens, pp 57.

Liener, I.E. (1982). Toxic constituents in Legumes. In *Chemistry and Biochemistry of Legumes* edited by S.K. Arora oxford and IBH Publishing Co; NewDelhi pp.217-257.

Lolas, G.M. and Markakis, P. (1975). Phytic acid and other phosphorus compounds of beans *Journal of Agriculture and Food Chemistry*. **23** : 13-15.

Longe, O.G. (1983). Varietal differences in chemical characteristics related to cooking quality of cowpea. *Journal of Food Processing and Preservation*. **7** (3): 143-150.

Lowgen, M. (1988). The effect of hull on the protein quality of brown beans *(P. vulgaris L.) Nutrition Report International* **38** (4): 873 - 883.

Lyenger, A.K. and Kulkarni, P.R. (1977). Oligosaccharides levels of processed legumes. *Journal of Food Science and Technology* **14** : 222.

Mahadevappa, V.G. and Rama,P.L. (1983). Hypocholesterolaemic effect of cowpea in rats on atherogenic diet. *Indian Journal of Medical Research* **78** : 819 - 823.

Mandal, N.C., Burman, S. and Biswas, B.B. (1972). Isolation purification and characterization of phytate from germinating mungbeans.

hytochemistry **11**: 465- 496.

Manorama, R. and Sarojini, G. (1982). Effect of different heat treatments on the trypsin inhibitor activity of soyabeans. *Indian Journal of Nutrition and Dietetics* 19:8.

Margaret M. Cobb and Howard Teitlebaum (1994). Determinants of plasma cholesterol responsiveness to diet. *British Journal of Nutrition* **71** : 271 - 282.

Mathur, K.S. Khan, M.A. and Sharma, R.D. (1968). Hypocholesterolaemic effect of Bengalgram. *Journal of Assoc. Physic India*. **13** : 923-928.

Mbajuna Obinna Kingsely (1995). Effect of processing on some antinutritive and toxic components and on the nutritional composition of the African oil bean seed *(Pentaclothra Macrophylla Benth) Journal of the Science of Food and Agriculture* **68** (2): 153 - 158.

Meiners, C.R., Derise, N.L., Lau, H.C., Ritchey, S.J. and Murphy E.W. (1976). Proximate composition and yield of raw and cooked mature dry legumes. *Journal of Agriculture and Food Chemistry* **24** : 1122-1126.

Michael Eskin N.A. and Wiebe S. (1983). Changes in phytase activity and phytate during germination of two fababean cultivars. *Journal of the science of Food and Agriculture* **48** : 270-271.

Miller, G.A., Youngs, V.I ., and Oplinger, E.S. (1980). Environmental and cultivar effects on oat phytic acid concentration. *Cereal Chemistry* **57** : 189-191

Mitjavila, S., Lacombe, C., Carrera, G. and Derache, R. (1977). Tannic acid and oxidized tannic acid on the functional state of rat in testinal epithelium. *Journal of Nutrition*, **107** : 2113.

Monica Lyimo., Jovin Mugula and Theresia Elias (1992). Nutritive composition of Broth from selected Bean varieties cooked for various periods. *Journal of the science of Food and Agriculture* **58** (3): 535-539.

Muller, F.M. (1967). Cooking quality of pulses. *Journal of the Science of Food and Agriculture* **18**: 292-295.

Muraleedhara Kurup, G. (1984). The role of protein and amino acid on the metabolism of lipids. glycosamino glycans and glycoproteins in experimental animals fed normal and atherogenic diet, *Ph.D. Thesis*, Kerala university.

NACNE (National Advisory Committee on Nutrition Education) (1983). A discussion paper on proposals for nutritional guidelines for health education in Britan. London. Health Education Council

Nagata, V., Tanaka, K. and Sugano, M. (1981). Further studies on the hypocholesterolemic effect of soyabean protein in rats. *British Journal of Nutrition* **45** : 233-241.

Nagata, Y., Ishiwaki, N. and Sugano, M. (1982). Studies on the mechanism of antihypercholesterolemic action of soy protein and soy protein type amino acid mixtures in relation to the casein counterparts in rats. *Journal of Nutrition* **112** : 1614-1625.

Narasimha, H.V. and Desikachar, HSR. (1978). Simple procedures for reducing the cooking time of split redgram *(Cajanus cajan) Journal of Food Science and Technology* **15**: 149 - 152.

Narpinder Singh., K.S. Sekhon., Usha Bajwa and Shyama Gopal (1992). Cooking and parching characteristics of chickpea (*Cicer arietinum L.*) *Journal of Food Science and Technology* **29** (6): 347 - 350.

Nawab Khan., Rashida Zaman and Manzoor Elahi (1988). Effect of processing on the phytic acid content of Bengalgram products *Journal of Agricultural Food Chemistry*, **36**: 1274-1276.

Neerjarani and Charanjeet K. Hira. (1993). Effect of various treatments on nutritional quality of fababean (*Vicia faba*) *Journal of Food Science and Technology* **30** (6): 413-416.

Neerjarani and Hira, C.K. (1994). Effect of various treatments on nutritional quality of Fababeans. *Food Science and Technology Abstract* **26** (3): 115.

Nehad, M.A. and Moneum (1990). Effect of presoaking on fababean enzyme inhibitors and polyphenols after cooking. *Journal of Agricultural Food Chemistry* **38** (8) 1479-1482.

Nepokroeff, C.M., Lakshmanan, C.M., Ness, G.C., Dugan, R.E. and Porter, J.W. (1973) Stimulation by insulin of rat liver ß - hydorxy - ß methylglutaryl coenzyme A reductase and cholesterol synthesizing activities. *Biochem. Biophys. Res. Commun.* **50** : 701 - 710.

Ningsanond, S. and Oovaikal,. B. (1989). Chemical and nutritional properties of dry and wet milling products of red cowpea. *Canadian Institute of Food Science and Technology Journal.* **22** (2) : 147-155.

Nnanna, I.A. (1988). Reduction of oligosaccharide content of cowpea (*Vigna unguiculta*) by germination and a study of changes in nutritional and functional quality of treated flour. *Dissertation Abstracts International.* **49** (5) : 1458.

Nnanna, I.A. and Phillips, R.D. (1989). Amino acid composition, protein quality and water soluble vitamin content of germinated cowpeas (*Vigna unguiculata*) *Plant Foods for Human Nutrition* **39** (2) : 187-200.

Nolan, K.B. and Duffin P.A. (1987). Effect of Phytate on mineral bioavalability. *Invitro* studies on Mg^{++}, Ca^{2+} Fe^{3+} Cu^{2+} and Zn^{2+} solubilities in the presence of phytate. *Journal of the Science of Food and Agriculture* **40**: 79-83.

Noor, I. R., Bressani and L.G. Elias. (1980). Changes in chemical and selected biochemical components, protein quality and digestibility of mungbean (*Vigna radiata*) during germination and cooking. *Qualitas Plantorum Plant Foods for Human Nutrition.* **30** : 135-145.

Noseda, G., Fragiacoma, C., Descorich. G. C., Fumayalli, R., Bernini, F. and Sirtori, C.R (1980). Clinical studies on the mechanism of action of the soyabean protein diet. In *Drugs affecting lipid metabolism* eds R. Fumagalli.,D. Kritchevsky and R. Paoletti, Amsterdam: Elsevier North Hoppand Biochemical Press.

Nowacki, E. (1980). Heat stable antinutritional factors in leguminous plants. *Advance in Legume Science - Proceedings of the international legume conference,* Vol.1 Royal Botanic Gardens, Kew, PP 171-177.

Oakenfull, D. (1981). Saponins in Food - Review *Food Chemistry* 7: 19-40.

O'Dell, B.L. and De Boland, A. (1976). Complexation of phytate with proteins and cations in corn and oilseed meals. *Journal of Agricultural Food Chemistry.* **24**: 804-808.

Ogun, P.O., Markakis, P. and Chenoweth, W. (1989). Effect of Processing on certain anti-nutrients in cowpea (*Vigna unguiculata*). *Journal of Food Science* **54**(4): 1084-1085.

Ohage, A.R., Patil, N.D. and Kadam, S.S. (1984). Influence of phosphorus fertilization on total and phytate 'P' of blackgram. *Journal of Maharashtra Agricultural University* **9**: 77 - 79.

Oke, O.L. (1965). Phytic acid phosphorus content of Nigerian food stuffs. *Indian Journal of Medical Research* **53**: 417 - 420.

Ologhobo, A.D. (1980). Biochemical and Nutritional studies of cowpea and lima bean with particular reference to some inherent anti-nutritional factors. *PhD thesis*, University of Ibadan, Ibandan, Nigeria.

Ologhobo, A.D. and Fetuga, B.L. (1982). Chemical composition of promising cowpea (*Vigna unguiculata*) varieties. *Nutrition Report International* **25** (6): 913-919.

Ologhobo, A.D. and Fetuga, B.L. (1983). Trypsin inhibitor activity in some limabean (*P. lunatus*) varieties as affected by different processing methods. *Nutrition Report International.* **27** (**1**): 41-49.

Ologhobo, A.D. and Fetuga, B.L. (1984). Distribution of phosphorus and phytate in some nigerian varieties of legumes and some effects of processing. *Journal of Food Science.* **49** : 199-201.

Onayemi, O., Osibopguni, O.A. and Obembi, O. (1986). Effect of different storage and cooking methods on some biochemical, nutritional and sensory characteristics of cowpea (*Vigna unguiculata* L. walp). *Journal of Food Science* **51** : 153-156.

Onigbinde, A.O. and Akingele, I.O. (1983). Oligosaccharide content of 20 varieties of cowpea in Nigeria. *Journal of Food Science* **48** : 1250-1254.

'Oyenuga, V.A .(1978). Nigeria's Foods and Feeding Stuffs : Their chemistry and Nutritive value Ibadan University Press, Ibadan Nigeria.

Pal, H., Chopra, A.K. and Bhat, C.M. (1975). The nutritive value of pressure cooked blackgram, greengram and lentil. *Journal of Punjab Agricultural University* **12** (3): 264 -271. Patil, V.P., Raut. V.M., Halvankar, G.B. and Taware, S.P. (1989). Stability analysis for seed yield and its components in soyaben. *Proc. World Soybean Research Conference* IV:**2**: 1042-1047.

Patil, S.J., Venugopal, R., Goud, J.V. and Parameshwarappa, R. (1989). Correlation and path coefficient analysis in cowpea. *Karnataka Journal of Agricultural Science* **2** (3): 170-175.

Patwardhan, V.N. (1962). Pulses and beans in human nutrition, *American Journal of Clinical Nutrition.* **1**: 107-110.

Pawar, V.D. and Ingle,. V.M. (1987). Production of quick cooking mothbean (*Phaselous conitolius Iuiq*) 11 Phytate phosphorus and minerals. *The Indian Journal of Nutrition and dietetics* **24**: 142 - 146.

'Pawastien, P. and King R.D. (1984). Changes in raffinose, stachyose, verbascose and L.Galactosidase activities in germinating winged beans. *Lebensmittel - Wissenchaft and Technologie* **17**(6) : 336 - 338.

Phillips, R.D. (1993). Starchy legumes in human nutrition health and culture. *Plant Food for Human Nutrition* **44**(3): 195 - 213.

Phirke, A.V., Chavan, J.K., Jadhav, S.J. and Salunke, D.K. (1982). Physical properties, chemical composition, cookability and solubilization of proteins of dry beans (*Phaseolus vulgaris* L.) *Legume Research.* 5 : 91-96

Price, K.R., Lewis, J., Wyatt, G.M. and Fenwick, G.R. (1988). Flatulence-causes, relation to diet and remedies. *Die Nahrung* **32** : 609-626.

Purie, M.L., Hagermlan. A.E.and Butler, L.G. (1980). Tannin content of cowpeas, chickpeas, pigeonpeas and mungbeans. *Journal of Agriculture and Food Chemistry.* **28**(2) : 459-461.

Rachis, J.J., Honig, O.H., Sessa, D.J. and Steggerda, F.R. (1970). Flavour and flatulance factors in soyabean products. *Journal of Agriculture and Food Chemistry* **18** : 977.

Raghuramulu, N., Madhavan Nair, K. and Kalyana Sundaram (1983). *Food analysis - A manual of laboratory Techniques.* National Institute of Nutrition, Indian Council of Medical Research, Jamai - Osmania Hyderabad.

Rajmohan, T. (1989). Dietary protein and metabolism of lipids and connective tissue macromolecules. *Ph.D. Thesis* Kerala University.

Rao, S., Basappa, C. and Sreenivas, V. (1979). Studies on the occurance of ochra toxins in food grains. *Journal of Food Science and Technology*, **16**(3): 113 - 114.

Rao, P.U. and Belavady, B. (1978). Oligosaccharides in pulses: varietal differences and effects of cooking and germination. *Journal of Agricultural Food Chemistry* **26**: 316 - 319.

Rao, P.U. and Deosthale, Y.G. (1982). Tannin content of pulses: varietal differences and effects of germination and cooking. *Journal of the Science of Food and Agriculture* **33**: 1012 - 1016.

Rao, P.U. and Deosthale, Y.G. (1983). Effect of germination and cooking on mineral composition of pulses. *Journal of Food Science and Technology* **20**: 195 - 197.

Rao, V., Destefano, M.V., Perez, C.R. and Barreiro, J.A. (1989). kinetics of thermal inactivation of protease (trypsin and chymotrypsin) inhibitors in black bean (*Phaseolus vulgaris*) flours. Journal of Food Science **9**: 35 - 46.

Rao, S.K., Gupta, A.K. and Tiwari, A.S. (1988). Nutrient composition and protein quality in mungbean. *Legume Research*, **2**(1): 11-18.

Rao, P.U. and Prabhavathi, T. (1982). Tannin content of foods commonly consumed in India and its influence on ionizable iron. *Journal of the Science of Food and Agriculture* **33**: 89.

Rao, V.S. and Vamil, U.K. (1983). Effects of gamma irradiation on flatulence causing oligosaccharides in greengram (*Phaseolus aureus*). *Journal of Food Science* **48**: 1791.

Ravindran, V. and Ravindran. C. (1988). Nutritional and antinutritional characteristics of Mucuna (*Mucuna Utilis*) bean seeds. *Journal of the Science of Food and Agriculture* **46**: 71 - 79.

Reddy, N. R., Balakrishna, C.N. and Salunkhe, D.K. (1978). Phytate, phosphorus and mineral changes during germination and cooking of blackgram (*phaseolus Mungo*) seeds. *Journal of Food Science* **43**: 540.

Reddy, N.R. Pierson, M.D., Sathe, S.K. (1985). Dry bean tannins: A review of nutritional implications. *Journal of Association of Officials of Analytical Chemistry.* **62**: 541- 549.

Reddy, N.R., Pierson, M.D., Sathe, S.K. and Salunkhe, D.K. (1984). Chemical, nutritional and physiological aspects of dry bean carbohydrates: a Review *Food Chemistry* **13**: 25 - 68.

Reddy, N.R., Pierson, M.D., Sathe, S.K. and Salunkhe, D.K. (1985). Dry bean tannins: a review of nutritional implications. *Journal of American oil Chemists Society* **62**: 541-549.

Reddy S.J., Pubols, M. and Mc Ginnis, J. (1979). Effect of gamma irradiation on nutritional value of dry field beans (*Phaseolus vulgaris*) *Journal of Nutrition* **109**: 1307 - 1312.

Reddy, M.V. and Pushpamma, P. (1986). Effect of storage on amino acid and biological quality of proteins in different varieties of pigeonpea, greengram and chickpea. *Nutrition Reports International* **33**(6) : 1021-1028.

Reddy, N.R. and Salunkhe, D.K. (1980). Changes in oligosaccharides during germination and cooking of blackgram and fermentation of blackgram/rice blend *Cereal Chemistry* **57**: 356.

Reddy, N.R., Salunkhe, D.K. and Sharma, R.P. (1980). Flatulence in rats following injestion of cooked and germinated blackgram and fermented products of blackgram and rice blend. *Journal of Food Science* **45**: 1161.

Reddy, N.R., Sathe, S.K. and Salunkhe, D.K. (1982). Phytates in legumes and cereals. *Adv. Food Res.* **28** : 1-90.

Reyes, Moreno C., Carabez- Terjo A., Paredes - Lopez, O. and Ordorica-Falomir, C.(1994). Physicochemical and structural properties of two bean varieties which differ in cooking time and the HTC characteristic. *Food Science and Technology* **27** (4) : 331-336.

Richard,I. Somiari and Esther Balogh (1992). Effect of soaking, cooking and crude _ galactosidase treatment on the oligosaccharide content of cowpea flours. *Journal of the Science of Food and Agriculture* **61** : 339-343.

Rockland, L.B., Zaragoza, E.M., Oracca - Tettech, R. (1979). Quick cooking wingedbeans (*Psophocarpus tefragonolobus*) *Journal of Food Science* **44**: 1004 - 1007.

Romero, J. and Ryan, D.S. (1978). Susceptibility of the major storage protein of the bean, *Phaseolus vulgaris* L; to *in vitro* enzymatic hydrolysis. *Journal of Agriculture and Food Chemistry* **26**: 784 - 788.

Rosaiah, G., Santhakumari, D., Satyanarayana, A., Rajarajeswari, V., Naidu, N.V. and Umaid Singh (1993). Cooking quality and nutritional characters of mungbean (*Vigna radiata* (L) Wilczek) varieties. *Journal of Food Science and Technology* **30** (3) : 219 - 221.

'Rossander, L. (1987). Effect of dietary fibre on iron absorption in man. *Scand Gastroenterol* 22 (suppl 129) 68 - 72.

Ryan, C.A. and Farmer, E.E. (1991). Oligosaccharide signals in plants: a current Assess ment. *Annual Review of Plant Physiology and Molecular Biology* **42**: 651- 674.

Salen, G., Ahrens, E. H.Jr., and Grundy, S.M. (1970). Metabolism of ß - Sitosterol in man. *Journal of Clinical Investigation* **49**: 952 - 967.

Sadasivam, S. and Manikam, A. (1992). *Biochemical methods for Agricultural Sciences*. Tamil Nadu Agricultural University, Combatore: 241.

Salunkhe,D.K. (1982). Legumes in human nutrition : Current status and f uture research needs, *Current Science.* **51** : 387-394.

Saraswathy Devi, K. and Kurup, P.A. (1970). Atherosclerosis. **11** : 479. Salunkhe, D.K., Kandam, S.S. and Chavan, J.K. (1985). Chemical composition. In: *Post harvest Biotechnology of Food legumes* CRS press, Boca Raton. FL, pp 29 - 52.

Santosh Khokhar and Chauhan, B.M. (1986). Antinutritional factors in mothbean (*Vigna aconitifolia*): varietal differences and effects of methods of domestic processing and cooking. *Journal of Food Science* **51** (3): 591 - 594.

Sathe, S.K. Deshpande, S.S., Reddy, N.R., Goll, D.E. and Salunkhe, D.K. (1983). Effect of germination on proteins, raffinose, oligosaccharides and antinutritional factors in the great northern beans (*Phaseolus vulgaris* L) *Journal of Food Science* **42**: 1796 - 1800.

Sathe, S.K. and Salunkhe, D.K. (1981). Studies on trypsin and chymotrypsin inhibitory activities, haemagglutinating activity and sugars in the Great Northern beans (*Phaseolus vulgaris* L) *Journal of Food Science* **46**: 626 - 629.

Sathe, S.K. and Salunkhe, D.K. (1984). Technology of removal of unwanted components of dry bean. *CRC Critical Review Food Science Nutrition*. **21**: 263-286.

Savitri, A. and Desikachar, H.S.R. (1985). A comparative study of flatus production in relation to the oligosaccharide content of some legumes. *Nutrition Report International.* **31** : 337.

Sefa-Dedeh, S. and Stanley, D.W. (1979). The relationship of microstructure of cowpeas to water absorption and dehulling properties. *Cereal Chemistry.* **56** : 379-386.

Serraino, M.R., Thompson, L.U., Savoie, L. and Parent, G. (1985). Effect of phytic acid on the *in vitro* rate of digestibility of rape seed protein amino acid. *Journal of Food Science* **50**: 1689 - 1692.

Sgarbieri, V.C. (1989). Composition and nutritive value of beans (*Phaseolus vulgaris* L) *World Review of Nutrition and Dietetics* **70** : 132 - 186.

Sharma. A. (1989). Effect of processing and cooking methods on nutrient composition and antinutritional factors of Bakla (*Vicia faba*). *M.Sc Thesis.* Haryana Agricultural University, Hisar, India.

Sharma, A.K., Bakhshi, A.K. and Varma, M.M. (1991). Proximate composition and nutrtional quality of some improved varieties of mungbean (*Vigna radiata*) *Legume Research* **14** (4) 197 - 200.

Sharma, Y.K., Tiwari, A.S., Rao, K.C. and Misra, A. (1977). Studies on chemical constituents and their influence on cookability in pigeonpea *Journal of Food Science and Technology.* **14**: 38 - 40.

Shindi, G.B., Adsule, R.N. and Kale, A.A. (1991). Effect of dehulling and cooking treat ments on phytate, phosphorus, polyphenols and trypsin inhibitor activity of cowpea seeds. *Indian Food Packer.* **45**(2): 63 - 65.

Shivashankar, G., Rajendra, B.R., Vijayakumar, S., Sreekantaradhya , R. (1974). Variability for cooking characteristics in a collection of greengram (*Phaseolous aureus Roxb.) Journal of Food Science and Technology.* **11**: 232 - 234.

Silva, H.C. and Braga, G.L. (1982). Effect of soaking and cooking on the Oligosaccharide content of dry beans (*Phaseolus vulgaris*, L) *Journal of Food Science* **47**: 924-925.

Simpson, K.M., Morris, E.R. and Cook, J.D. (1981). The inhibitory effect of bran on iron absorption in man. *American Journal of Clinical Nutrition.* **34**: 1469 - 1478.

Singh, U. (1984). The inhibition of digestive enzymes by polyphenols of chickpea (*Cicer arietinum* L.) and pigeonpea (*Cajanus cajan* L) *Nutrition Report International* **29**: 745 - 753.

Singh, D.H. and Banerjee, S. (1953). Studies on the effect of germination on the availability of iron in some common Indian pulses. *Indian Journal of Medical Research*, **43**: 497 - 500.

Singh, U. and Eggum, B.O. (1984). Factors affecting the protein quality of pigeonpea (*Cajanus cajan* L.) *Plant Foods for Human Nutrition*. **34**: 273 - 283.

Singh, R., George, M. and Soni, G.L. (1983). Role of dietary fibre from pulses as hypocholesterolemic agent *Journal of Food Science and Technolog* **20**:228-230.

Singh, V. and Jambunathan, R. (1981) Studies on Desi and Kabuli chickpea (*Cicer aritinum* L.) cultivars : Levels of protease inhibitors, levels of polyphenolic compounds and *in vitro* protein digestibility. *Journal of Food Science* **46**: 1364-1367.

Singh, U. and Jambunathan, R. (1982). Distribution of seed protein factors and amino acids in different anatomical parts of chickpea (*Cicer arietinum* L) and pigeonpea (*Cajanus cajan* L.) *Plant Foods for Human Nutrition*. **31** : 347-354.

Singh,M. and Krikorian, A.D. (1982) Inhibition of trypsin activity in *invitro* by phytate. *Journal of Agriculture and Food Chemistry* **32** : 799.

Singh, V., Rao, P.V., Seetha, R. and Jambunathan, R. (1989). Nutrient losses due to scarification of pigeonpea (*Cajanus cajan*) cotyledon *Journal of Food Science*, **54**: 974 - 976.

Singh, U., Santosa, B.A.S. and Rao, P.V. (1992). Effect of dehulling methods and physical characteristics of grains on dhal yield of pigeonpea (*Cajanus cajan* L.) genotypes. *Journal of Food Science and Technology* **29** (6): 350 - 353.

Singh, V. and Singh, B. (1992). Tropical grain legumes as important human foods. *Econ Bot* **46** : 310-321. Singh, V., Subrahmanyan, N. and Kumar, J. (1991). Cooking quality and nutritional attributes of some newly developed cultivars of chickpea (*Cicer arietinum* L.) *Journal of the Science of Food and Agriculture* **55**: 37-46.

Singh, K.B., Williams, P.C. and Nakkoul, H. (1990). Influence of growing season, location and planting time on some quality parameters of Kabuli chickpea. *Journal of the Science of Food and Agriculture.* **53**: 429 - 441.

Snook, J.T., De Lancy, J.P. and Vivian, V.M. (1985). Effect of moderate to very low fat defined formula diets on serum lipids in healthy subjects. *Lipids* 20: 808 - 816.

Soni, G.L., George, M. and Singh, R. (1982). Role of common Indian pulses as hypocholesterolaemic agents. *Indian Journal of Nutrition and Dietetics* **19**: 184 - 190.

Sood, D.R., Tek Ram and Kuldip Singh Dhindsa (1991). Nutritional and cooking evaluation of blackgram (*Vigna mungo* L. Hepper). *Legume Research.* **29** (2): 99-103.

Sood, D.R., Wagle, D.S. and Singh, K.D. (1982). Studies on the nutritional quality of some varieties of mungbean. *Journal of Food Science and Technology* **19** : 123- 124.

Sosulski, F.W., Elcovicz, L. and Reichert, R.D. (1982). Oligosaccharides in eleven legumes and their air classified protein and starch fraction. *Journal of Food Science* **47**: 498.

Sotelo, A. and Hernendez, M. (1980). Nutritional evaluation of 3 varieties of beans (*P. vulgaris*) using chemical and biological methods. *Nutrition Report International* **22** (4) : 606 - 616.

'Souci, S.W., Pachmann, W. and Kraut, H. (1986). Food Composition and Nutrition Tables. *Wissen Schaftliche Verlagsgesellschaft mbh, Stuttgart.*

Srivastava, S., Mishra, D.P. and Khare, B.P. (1988). Effect of insect infestation on bio -chemical composition of pigeonpea seeds stored in mudbins.*Bulletein of Grain Technology*, **26**(2) : 120 - 125.

Subhalakshmi, G., Kumar, K.G. and Venkataraman, L.V. (1976). Effect of germination on the carbohydrates, proteins, trypsin inhibitor, amylase inhibitor and haemagglutinin in horsegram and mothbean. *Nutrition Report International.* **13**: 19-31.

Sugimoto, H. and Van Buren, J.P. (1970). Removal of Oligosaccharides from soy milk by an enzyme from Aspergillus saitoi. *Journal of Food Science* 35: 655- 660.

Summerfield , R.J., Huxley, P.A. and Steel, W. (1974). Cowpea (*Vigna unguiculata* (L) walp) *Field Crop Abstracts* **27**: 301 - 312.

Sunday Y. Giami and Uzodema I. Okwechime. (1993). Physicochemical properties and cooking quality of four new cultivars of Nigerian cowpea (*Vignaunguiculata* L Walp) *Journal of the Science of Food and Agriculture* **63**: 281 - 286.

Suneeta Kumari, Bhattacharya, L. and Singh, D.P. (1983) Chemical composition of improved varieties of mungbean (Vigna radiata L. Wilczek). Seeds and Farms,9 : 27-28.

Susan M. Kingman., Ann F. walker and A,G. Low and I.E. Sambrook (1993). Comparative effects of four legume species on plasma lipids and faecal steroid excretion in hypercholesterolaemic pigs. *British Journal of Nutrition*. 69 : 409-421.

SusanM. Shutler., Ann F Walker and A. Graham Low (1987). The cholesterol lowering effects of legumes: I: Effects of the major nutrients. *Human Nutrition: Food Science and Nutrition* **41**.F: 71 - 86.

'Susan M. Shutler., Gemma, M. Bircher., Jacki, A. Tredger., Linda, M. Morgan., Ann F. Walker and A.G. Low (1989). *British Journal of Nutrition* **61**: 257 - 265.

Sylvester O. Iqbedioh., Kehinda, T. Olugbemi and Maurice A. Akpapunam (1994). Effect of processing methods on phytic acid level and some constituents in bambara groundnut (*Vigna subterranea*) and pigeonpea. (*Cajanuscajan*). *Food Chemistry.* **50**: 147-151

Tabekhua, M.M. and Luh, B.S. (1980). Effect of germination, cooking and canning on phosphorus and phytate retention in dry beans. *Journal of Food Science*. **45** : 406-410.

Tan, N.M. and Wong, K.C. (1982). Thermal stability of trypsin inhibitor activity in wingedbean (*Psophocarpus tetragogolobus) Journal of Agricultural Food Chemistry* **30**: 1140.

Tan N.H., Wong, K.C., de Lumen, B.O. (1984). Relationship of tannin and trypsin inhibitor activity with the *in vitro* protein digestibility of raw and heat treated wingedbean (*Phaseolus tetragonolobus*) *Journal of Agriculture and Food Chemistry* **32**: 819 - 822.

'Tang, J., Sokhansanj, S., Sosulski, F.W. and Slinkard, A.E. (1990). Effect of swathing and moisture content on seed properties of lentil. *Canadian Journal of plant Science*, **70**: 1173 - 1178

Tang, J., Sokhansanj, S., Sosulski, F.W. and Slinkard, A.E. (1992). Effect of harvest method on moisture content and quality of lentil seeds. *Canadian Journal of Plant Science*, **72**: 451 - 456

Terri D. Drumm., J. Ian Gray., George, L. Hosfield and Mark A. Uebersax (1990). Lipid, saccharide, protein, phenolic acid and saponin contents of four market classes of edible dry beans as influenced by soaking and canning. *Journal of the Science of Food and Agriculture* **51**: 425- 435.

Tezoto, S.S. and Sgarbieri, V.C. (1990). Protein nutritive value of a new cultivar of bean (*Phaseolus vulgaris*). *Journal of Agriculture and Food Chemistry* **38** (4):1152 - 1156.

Thomas, J.A. and H. Doll. (1979). Genetic and evaluation of seed protein. *Seed protein improvement in cereals and grain legumes.* International Atomic Energy Agency, Vienna, Vol. 1.

Thompson, L.U. and Yoon, J.H. (1984). Starch digestibility as affected by polyphenols and phytic acid *Journal of Food Science.* **49**: 1228-1229.

Topping, D.L., Storer, G.B., Calvert, G.D., Illman, R.J., Oakenfull, D.G. and Weller, R.A. (1980). Effects of dietary saponins on faecal bile acids and neutral sterols, plasma lipids and lipoprotein turnover in the pig. *American Journal of Clinical Nutrition* **33**: 783 - 786.

Trappy, L., Warsch, P., Randin, J.P., Felber, J.P. and Jequier. E. (1986). Metabolic effect of pre-cooked instant preparations of bean and potato in normal and in diabetic subjects *American Journal of clinical Nutrition* **43**: 30 - 36.

Trung, B.C. and Yoshida, S. (1982). A comment on the varietal differences of production of mungbean and its grain properties. *Soil Science and Plant Nutrition* **28**: 413 - 417.

Tuan, Y.H. and Phillips, R.D. (1992). Nutritional quality of hard to cook and processed cowpea *Journal of Food Science.* **57** (6) : 1371-1374.

'Udayasekhara Rao, P. and Deosthale, Y.G. (1982). Journal of the Science of Food and Agriculture *Pulse Production* 388.

Umaid Singh., Nukala Subrahmanyam and Jagdish Kumar (1991). Cooking quality and nutritional attributes of some newly developed cultivars of chickpea (*Cicer arietinum*) *Journal of the Science of Food and Agriculture.* **55**: 37-46.

Umaid Singh., Paleti Venkateswara Rao., Nukala Subrahmanyam and Kulbhushan Saxena (1993). Cooking characteristics, chemical composition and protein quality of newly developed genotypes of pigeon pea (*Cajanus cajan* L) *Journal of the Science of Food and Agriculture.* **61**: 395 - 400.

Umaid Singh., Ramamurthi Jambunathan., Kulbhushan Saxena and Nukala Subrahmanyam (1990). Nutritional quality evaluation of newly developed high protein genotypes of pigeonpea (*Cajanus cajan*) *Journal of the Science of Food and Agriculture.* **50**: 201-209.

Usha, C., Lalitha, B. and Rajammal, D.P. (1981). Evaluation of protein quality of raw, roasted and autoclaved legumes supplemented with sulphur containing amino acids. *Indian Journal of Nutrition and Dietetics* **18** (8) : 283 - 288.

Vanderstoep, J. (1981). *Food Technology* **35** (3) : 83 - 85.

Umaegbute, A.C. and Nnanyelugo, D.O. (1987). Nutritive value and biological evaluation of processed cowpea diets compared with local weanling foods in Nigeria, *Nutrition Report International.* **36** (1) : 119.

Van Handel, E. and Zilversmit, D.B. (1957). *J. Lab and Clin. Med.* **50** : 152.

Veerappa H. Mulimani and S. Paramjyothi (1992). Proteinase Inhibitors of redgram (*Cajanuscajan*). *Journal of the Science o Food and Agriculture* **59**: 273 - 275.

Venugopal Padmanabhan Menon (1976). Effect of proteins and carbohydrates on the metabolism of glycosaminoglycans in relation to atherosclerosis. *PhD Thesis*, Kerala University.

Vimala, V. and Pushpamma, P. (1987). Storage changes in cookability of pulses from three regions of Andhra Pradesh. *Journal of Food Science and Technology* **24** (4): 155-158.

Vishalakshi, I., Salunkhe, D.K., Sathe, S.K. and Rockland, L.B. (1980). Quick- cooking beans (*Phaseolus vulgaris*) II. Phytates, oligosaccharides and antienzymes. *Qualitas Plantorum Plant Foods for Human Nutrition* **30**: 45 - 52.

Wagner J.R., Becker, R., Gumbmann, M.R. and Olson, A.C. (1976). Hydrogen production in the rat following injestion of raffinose, stachyose and oligosaccharides free bean residues. *Journal of Nutrition.* **106**: 466 - 470.

Weisweiler, P., Janetschek, P. and Schwandt, P. (1986). Fat restriction alters the composition of apolipoprotein B-100 containing very low density lipoproteins in humans. *American Journal of Clinical Nutrition* **43**: 903 - 909.

Welch, C.A., Laehanee, P.A. and Wasserman, B.P. (1989). Dietary phenolic compounds: in hibition of rat dependent D glucose uptake in rat intestinal bush border membrane vesicles. *Journal of Nutrition.* **119**: 1698.

Williams, P.C., Nakoul, H. and Singh, K.B. (1983). Relationship between cooking time and some physical characteristics in chickpea (*Cicer arietinum* L.) *Journal of the Science of Food and Agriculture* **34** : 492-496.

Williams, P.C. and Singh, V. (1987). The chickpea nutritional quality and the evaluation of quality in breeding programmes. In Saxena M.C. Singh K.B. (eds) *The chickpea*. Slough: CAB International.

Wilson, K.A. (1980). The release of proteinase inhibitor from legume seeds during germination. *Phytochemistry* **19**: 2517.

Winje, M.E., Harper, A.E., Benton, D.A., Boldt, R.E. and Elvehjem, C.A. (1954). *Journal of Nutrition.* **54**, 155.

Yadav, S. and Khetarpal, N. (1994). Indigenous legume fermentation: Effect on some antinutrients and *invitro* digestibility of starch and protein. *Food Chemistry* **50** : 403 - 406.

Yoon, J.H., Thompson, D.V. and Kenkins, J.D. (1983). The effect of phytic acid on *invitro* rate of starch digestion and blood glucose response. *American Journal of Clinical Nutrition* **38**: 835 - 840.

Zacharie Barampama and Ronald E. Simard (1994). Oligosaccharides, antinutritional factors and protein digestibility of dry beans as affected by processing. *Journal of Food Science* **59** (4): 833 - 838.

Zamora, A.F. and Fields, M.L. (1979). Nutritive quality of fermented cowpea (*Vigna sinensis*) and chickpea (*Cicer arietinum*) *Journal of Food Science* **44** (1): 234 - 236.

* Orginal not seen

APPENDIX

APPENDIX 1

	Cooking time		Volume	Expansion	Protein		NPU		UP		PER		FER	
	cowpea	green-gram	cowpea	green-gram	cowpea	green-gram	cowpea	green-gram	cowpea	green-gram	cowpea	green-gram	cowpea	green-gram
Grain weight	-.5337*	.3082	.0729	.0662	.6566**	.0795	-.7569**	-.7984	-.0324	-.6471	-.1168	-.1222	.4350	.1732
Grain volume	-.6578**	-.1929	.0420	.3653	.6144	-.3066	-.6845**	-.2032	-.0129	-.3360	-.2010	.0921	.4039	-.1399
Width	-.6651**	.6953**	.1265	.5541*	.6107*	.4098	-.6172*	-.3559	.0174	.0087	-.1396	.0725	.4275	.4626
Length width ratio	.7426**	-.4750	.4596	-.4586	.1493	-.3597	.7464**	.0668	.7665**	-.2429	.2067	.0602	.0880	-.2872
Length	.4683	.4734	.5996*	.2595	.5047	.2064	.4867	-.3744	.8669**	-.1806	.1588	.0886	.3370	.3723
Water uptake	-.1695	.1566	.2979	.7038**	.0892	-.5700**	.2254	-.0532	.2198	-.4032	.6066**	.2315	.5172	-.2076
Density	.6125*	.4195	.0632	-.3069	-.0721	.3697	.0627	-.3836	-.0178	-.1362	.2270**	.1872	-.1035	.2647
Protein	.0519	.4475	.3088	-.1791	1.000	1.000	-.1686	-.2055	.5904	.4527	.0538	.0247	.6216	.7185**
Ash	-.7113**	.5143*	.2103	-.1653	-.2157	.3725	-.0718	-.6213	-.663	-.3229	.2662	-.1892	.2823	.3152

Fiber	.7088**	-.0552	.4708	.0120	.1135	.5291*	.8365**	.4969	.7346**	.8370**	.3734	.2435	.1532	.4134
DC	.2312	-.4241	.2771	.0316	.2344	-.1860	.8043**	.8602**	.8227**	.6582**	.1026	.1262	.2472	-.2333
BV	.6117*	.3522	.1415	-.4208	-.6063**	-.0128	.5672*	.4172	-.0767	.3372	.0146	-.5219*	-.6257**	-.3605
NPU	.6318*	-.2213	.2381	-.1822	-.1686	-.2055	1.0000	1.000	.6390*	.7545**	.1127	-.1507	-.1485	-.4187
Methionine	-.8685**	-.2894	-.3075	-.2091	-.0193	.0238	-.3392	-.0677	-.3066	.0050	.1286	.2953	.3524	.1562
Cystine	-.5509**	.3942	-.4904	-.0140	-.0342	-.6147*	-.8692**	-.263.6	.7111**	.2235	-.1561	.2329	.0013	.6142*
Lysine	.4649	-.6020*	.5499*	.0453	.5800*	-.8087**	.0933	.6463**	.5780*	.0352	.0793	-.0202	.2852	-.6992**
Arginine	-.2686	-.2957	.3964	.0294	.8097**	.1603	-.1458	.7318**	.5655**	.7835**	.2863	.1928	.8167**	.0760
Tannin	-.5057	.4208	-.4021	-.0722	.0721	-.0324	-.8468**	-.6033*	-.6017*	-.5721*	-.4402	-.3614	-.1453	-.1049
Phytin	.5265	.3763	-.3730	-.2587	-.1484	.1066	-.8304**	.3442	-.7055**	.3701	.1172	-.4060	.1119	-.1411
Trypsin inhibitor	.0987	.3951	.1036	.2502	.3786	-.6891**	-.5975*	-.4493	-.0921	-.8830**	-.2961	.1059	-.0419	-.3470

*** Significant at 1 per cent level**

**** Significant at 5 per cent level**

ASSESSMENT OF QUALITY OF SELECTED VARIETIES OF GREEN GRAM AND GRAIN COWPEA

BY

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ABSTRACT OF THESIS

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ABSTRACT

Pulses contain several imbibed inhibitors, antinutritional substances and flatulence causing factors which negatively influences their nutritional significance, digestibility and utility value. Studies on processing pulses, indicate a reduction in the above undesirable factors.

Comprehensive information regarding the quality of different varieties of pulses evolved and recommended by Kerala Agricultural University are at present not available. Hence in this study, a critical assessment of the quality parameters in selected varieties of cowpea (C 152, V 118, Pournami, Kozhinjipayar and Kanakamany) and greengram (Mg 161, M 3, Co 2, Pusa 8793 and Pusa Baisakhi) were envisaged.

The physical, cooking, nutritional and antinutritional qualities were critically assessed to screen the varieties of the two pulses. Effect of processing and cooking methods on the above quality parameters were also ascertained.

Salient findings of the study are:

1. Based on the physical, cooking and nutritional characteristics Kanakamany in cowpea and Pusa 8793, M 3 and Mg 161 in greengram were found to be better than other varieties..pa

2. In Cowpea varieties tannin, phytin and trypsin inhibitors were lowest in V 118, raffinose in C 152; and stachyose and verbascose in Kozhinjipayar.

3. Among greengram varieties tannin, and verbascose were lowest in M 3; phytin and stachyose in Co 2, trypsin in Mg 161 and raffinose in Pusa 8793.

4. Gel electrophoretic analysis of cowpea and greengram protein revealed their heterogenic nature.

5. Limiting amino acids such as methionine and cystine were highest in Kanakamany (cowpea) and Mg 161 (greengram).

6. Biological experiments revealed that among cowpea varieties PER and NPU were highest for Pournami (1.92) and V 118 (86.13) respectively and in greengram varieties, PER was maximum for Mg 161 (2.83) and NPU was highest for Pusa Baisakhi (84.27).

7. Incorporation of Kanakamany (which was lysine and arginine ratio as 1) in high fat high cholesterol diet decreased the lipid level in liver and serum of experimental animals indicating the hypocholesterolemic effect of Kanakamany.

8. An increase in protein content was observed in the two pulses during germination and germination followed by steaming.

10. A reduction in antinutrients were found during various processing and cooking methods.

11. Soaking and boiling caused maximum reduction in tannin, phytin and trypsin inhibitor in the two pulses.

12. Germination and steaming were found to be the most effective method in reducing the flatus producing oligosaccharides viz raffinose, stachyose and verbascose in the two pulses.

13. Application of suitable statistical techniques on the above data revealed the superiority of Kanakamany (cowpea) and Mg 161 (greengram) over other varieties.