NUTRITIVE VALUE AND ACCEPTABILITY OF WINGED BEAN GENOTYPES

(*Psophocarpus tetragonolobus* L.)

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled '**Nutritive value and acceptability of winged bean genotypes (*Psophocarpus tetragonolobus* L.)**' 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 award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Dedicated to
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INTRODUCTION

Vegetables play an important role in human diet as an important source of protective foods. Yellow vegetables provide vitamin A and green vegetables furnish iron and vitamin A while all vegetables are good sources of minerals, vitamins and fibre. The young tender growing leaves contain more ascorbic acid than the mature plants.

Edible legumes are excellent sources of dietary proteins and oils. As the prospect of food shortages become more and more acute, people must depend increasingly on plants rather than animals for the protein in their diet National Academy of Sciences (NAS, 1975a). In addition to the major cultivated edible legumes like soybeans, peas and peanuts there are more than 50 minor tropical legumes that have received little scientific attention (NAS, 1975b).

Among the tropical legumes winged bean has gained much attention in recent years though the crop has been in cultivation in India since long. Masefield (1973) was the first to note the potentialities of this crop. World wide interest on winged bean especially as a protein rich and oil yielding crop was generated by the report of the National Academy of Sciences in 1975.

The winged bean, scientifically known as *Psophocarpus tetragonolobus* is also known as asparagus pea, goa-bean, four-angled bean, Manila bean and princess pea (Janoria *et al.*, 1984). Winged bean is a minor tropical legume which contains high amount of good quality protein Central Food Technological Research Institute (CFTRI, 1981). It is an exceptional legume and shows a great potential for overcoming the protein malnutrition problem in the humid tropics. This climbing bean is unique in that all parts of it are edible. The green pods, seeds and leaves are rich in protein and vitamins and the tuberous roots are - among the root crops - uniquely rich in proteins. In addition, the seeds are a source of edible oil.

Winged bean is a prolific climbing perennial or annual plant. It is a tropical short day plant well adapted to low land conditions and has a high water requirement. It is readily adaptable to varying soil and climatic conditions (Banerjee, 1985). Winged bean is suitable only for small scale farming because the vines require staking if high yields of pods and seeds are desired. Pods also mature unevenly and the plant is generally free of pests and diseases. The blue, white or purple flowers are self pollinating. The pods are four-sided with characteristic wings and contains 5-20 seeds in each pod.

Winged bean plants grow vigorously and have extensive root systems, with a multitude of exceptionally large nitrogen fixing nodules. All parts of the winged bean plant contain high levels of nitrogen and thus makes it a good green manure, cover crop or restorative fallow crop.

Large number of germplasm collections were evaluated in diverse climatic conditions and they varied in morphology, physiology, maturity and chemical composition. However, no such systematic study on the nutritive value and acceptability of the edible parts of winged bean has been conducted in Kerala. Hence the present study on the nutrient content and acceptability of the edible parts of winged bean genotypes was attempted with the following objectives.

1) To study the nutritional composition of the different edible parts - flowers, leaves, seeds, pods - of winged bean genotypes.
2) To evaluate the acceptability of the different edible parts - flowers, leaves, seeds, pods - of winged bean genotypes.

Review of Literature

REVIEW OF LITERATURE

In this chapter an attempt has been made to review the literature relevant to the study entitled "Nutritional composition and acceptability of winged bean genotypes".

The review has been done under the following sections.

1. Nutritional composition of under exploited vegetables
2. Nutritional composition of green leafy vegetables
3. Nutritional composition of legumes
4. Nutritional composition of winged bean
5. Antinutritional factors in winged bean
6. Acceptability of the different edible parts of winged bean
7. Cooking qualities of winged bean

2.1 Nutritional composition of under exploited vegetables

The main uses of vegetables in human diet are that they embelish the existing diet with nutrients, enrich the staple main food and make it more palatable and improve the digestion and have a curative action (Indira and Peter, 1988). The wide prevalence of protein-calorie malnutrition among the vulnerable segments of the population in many developing countries has led to world-wide search for unutilized and underutilized resources of foods rich in nutrients. One of the major reasons for malnutrition in developing countries is that food production cannot keep pace with the rapidly increasing population. According to Rao (1997) it is important to focus on under exploited food grains to replace or supplement the conventional cereals, pulses and oil seeds in the Indian diet and to overcome the deficit in calories and proteins.

As reported by CSIR (1972) the seeds of *Solanum nigrum* commonly called `manathakkali' contains 17.5 per cent protein and the fruits also contain glucose, fructose, vitamin C and carotene. *Solanum torvum* commonly called as `anachunda' is another under exploited vegetable and the dried fruits contain about 8.3 per cent protein, 12.3 per cent moisture, 1.7 per cent fat, 5.1 per cent minerals and 17.6 per cent crude fibre (CSIR, 1972).

The young shoots and tender leaves of Chaya, an under exploited vegetable is reported to be high in protein, calcium, iron, thiamine, riboflavin, niacin and ascorbic acid (NAS, 1975b).

Wax gourd popular in Asian tropics contain 4 per cent protein, 3.2 per cent carbohydrate and 0.1 per cent fat (NAS, 1975b). The seeds of buffalo gourd, a drought tolerant under exploited vegetable contains about 30 per cent protein and 34 per cent oil (NAS, 1975b).

Guar or *Cyanopsis tetragonoloba*, a leguminous herb resembling soybean contains 34 per cent protein and 40 per cent oil in its seeds (NAS, 1975b).

Dhanprakash *et al.* (1993) reported that the seeds of *Chenopodium* species contained 106-142 g/kg protein and 30-62 g/kg fat. The protein content of vegetable cowpea ranged from 2.5-5.94 per cent (Aghora *et al.* 1994).

According to Kuriakose (1995) the stolons of lotus which can be used as a vegetable is a fair source of protein (2.7%) and a poor source of fat (0.11%) and fibre (0.8%).

The unconventional leafy vegetables found in the forest and cultivable wasteland of Konkan, like drumstick leaves, math, katemath, bharangi and kawala contained comparitively higher amounts of crude protein, crude fat, ash, crude fibre and total carbohydrate (Shingade *et al.*, 1995).

2.2 Nutritional composition of green leafy vegetables

Green leaves are inexpensive sources of many nutrients essential for growth and maintaining normal health (Gopalan, 1989).

According to Peter (1979) and Nautiyal and Raman (1987) drumstick leaves are more nutritious than most of the vegetables commonly used. Green leafy vegetables are rich in minerals especially iron and calcium (Menon, 1980; Philip *et al.*, 1981; Gopalan, 1982; Smith, 1982). Ifon and Bassir (1980) studied the nutritive value of some Nigerian green leafy vegetables and reported that the ash content ranged from 9.7-18.6 per cent. Faboya (1983) reported an average of 20 per cent ash in the green leafy vegetables examined. According to Wills *et al.* (1984) non-brassica leafy vegetables popular in China contained 2.4-3.9 mg iron per 100 g while *Brassica* spp. contained only 0.3-1.7 mg iron per 100 g edible portion.

Besides calcium and iron, other minerals abundantly present in the green leafy vegetables are magnesium, phosphorus, sulphur, zinc, manganese, sodium, potassium and flourine. Of the 8 minerals determined in the green leafy vegetables by Faboya (1983) magnesium is the most abundant.

Green leafy vegetables are generally found to be rich in vitamins. Among the vitamins, vitamin C, carotene and vitamin B complex are found in abundance in green leafy vegetables. The drumstick leaves were reported to be richer in ascorbic acid than tomato, radish, carrot and peas (Peter, 1979 and Nautiyal and Raman, 1987). According to Bressani *et al.* (1986) green leafy vegetables are good sources of carotene. Besides vitamin C and carotene the green leaves are reported to contain tocopherols also (Gopalan, 1982).

Among the green leafy vegetables few were found to be rich in protein. According to Sehgal (1975) and Sawhney and Kawatra (1986) leafy vegetables like beet, knol-khol, turnip, mustard and spinach contained 23 to 32 per cent proteins and were well balanced with respect to essential amino acids. Peter (1979) reported that drumstick leaves contained 6.7 per cent of protein equivalent to that of peas while chekkurumanis leaves contained 6.8 per cent protein. Ifon and Bassir (1980) studied the nutritional value of some Nigerian green leafy vegetables and reported that the protein content ranged from 17.2-28.4 per cent on dry weight basis. According to Philip *et al.* (1981) curry leaves contained 6.1 per cent of protein. Vijayakumar and Shanmugavelu (1985) reported amaranthus as a rich source of protein. Among the nine green leafy vegetables grown in Eastern Uttar Pradesh abundantly, *Chinopodium album, Cicer arietinum, Brassica campestris* and *Spinacia oleracea* leaves were found to be rich in proteins and other biochemical constituents over the rest of the green leafy vegetables studied (Awasthi and Abidi, 1985). According to the authors the protein content in these green leafy vegetables ranged from 22.92-31.50 per cent on dry weight basis. Gupta *et al.* (1989) reported that the protein content in amaranth, drumstick, fenugreek and pumpkin varied from 25.1-28.5 per cent. Bathu, carrot and radish leaves contained 21-47 per cent protein on dry matter basis (Gopalan *et al.*, 1989). Studies by Dhanprakash and Pal (1991) on 10 species of amaranthus showed that the protein content ranged between

14-30 g/kg. The protein content in 10 species of *Chenopodium* foliage was found to vary between 26-64 g/kg.

A major component reported to be abundantly present in green leafy vegetables is fibre. Among the various types of green leafy vegetables, chekkurumanis leaves were found to contain 2.5 g per cent fibre (Ramachandran *et al.*, 1980). In curry leaves, the fibre content was 6.4 g per cent (Philip *et al.*, 1981). Wills *et al.* (1984) reported the fibre content of popular chinese green leafy vegetables as 1.1-4.5 per cent. According to Sreeramulu *et al.* (1983) among the green leafy vegetable grown in Tanzania fibre was highest in *Amaranthus viridis* (21.3 g/100 g) and lowest in *Moringa oleifera* (5.7 g/100 g). John *et al.* (1987) found that the richest source of total dietary fibre among the vegetables grown and consumed in South East Asia were *Pithecellobium jiringa, Hibiscus esculentus* and *Pisum sativum*.

Green leafy vegetables are not considered suitable food articles to meet the carbohydrate content. However a few studies on these lines present an entirely different picture. Ifon and Bassir (1980) reported the carbohydrate content of some Nigerian green leafy vegetables as 51.0-66.1 per cent. According to Ramachandran *et al.* (1980) the carbohydrate content of chekkurumanis leaves and curry leaves was 11.5 per cent and 16 per cent respectively. Sreeramulu *et al.* (1983) reported that many of the green leafy vegetables grown in Tanzania were good sources of carbohydrate.

As in the case of carbohydrate, green leafy vegetables were reported to be in general poor sources of fat. The range of fat content in green leafy vegetables which are commonly used in our country varies from 0.3 to 3 per cent. According to Philip *et al.* (1981) the fat content of curry leaves is 1.0 per cent.

2.3 Nutritional composition of legumes

Legumes are important sources of plant proteins for human consumption especially in the diets of people living in developing countries (Cerny and Addy, 1973; Rao and Sastry, 1991). Green immature legumes contribute ß carotene and ascorbic acid which are not usually present in mature dry seeds (Cerny and Addy, 1973). Pulses are most frequently considered in terms of their complementary nutritional value to cereal diets due to their high lysine contents (Hulse, 1991).

According to Aykroyd and Doughty (1982) legumes are good sources of nutrients, particularly proteins, calcium, iron, nicotinic acid and thiamine which complement staple items of the diet such as cereals. According to Salunkhe (1982) grain legumes supply major part of the dietary proteins in the vegetarian diet of the Indian subcontinent. Legumes contain 2-3 times more protein than cereals (Chavan *et al.*, 1987) and are also good sources of dietary carbohydrates (Rao, 1976). Food legumes have made significant contribution to human diets since ancient times (Bhatty, 1988).

However, legumes are deficient in sulphur containing amino acids methionine and cystine which account for their poor biological quality (Chavan *et al.*, 1994; Sangha *et al.*, 1994).

Varietal differences in protein and mineral contents of twenty five pulse varieties were observed by Kadwe *et al.* (1974). The authors reported that the protein contents ranged from 19.9-27.2 per cent. Sood *et al.* (1982) studied the nutritional quality of 9 varieties of mung beans and the protein content was found to vary from 23.92-27.72 per cent; crude fat 1.1-2.27 per cent; total carbohydrates 57.34-61.38 per cent and iron 3.7-8.8 mg per 100 g.

According to Janoria *et al.* (1984), the seeds of cluster bean contain upto 31 per cent protein. Dhindsa *et al.* (1985) reported that the protein content of lentil varieties ranged from 26.3-31.0 per cent; crude fat from 4.1-4.5 per cent; minerals 2.61-2.91 per cent and energy 405-429 K cal/100 g.

Vimala and Pushpamma (1982) reported high protein contents in green gram (23.62%), bengal gram (16.99%), red gram (20.33%) and black gram (21.95%). Awasthi and Abidi (1987) studied the protein content of seven varieties of chick pea and reported that the protein content ranged from 13.82-28.25 per cent. Ten improved varieties of cowpea were analysed by Fashakin and Fasanya (1988) for protein, iron and calcium and it was found to range from 21.5-27 per cent; 8-15 mg/100 g and 13.5-20.8 mg/100 g respectively.

Raghuvanshi *et al.* (1993) reported black gram as a good source of protein, water soluble vitamins as well as minerals. Mohan and Janardhanan (1993) studied the raw seeds of tribal pulses *Parkia roxburghii* and *Entada phaseoloides* and found that seeds of *Parkia roxburghii* contained high crude protein and lipids. Both the seeds were rich in potassium as well as iron. Seeds of *Entada phaseoloides* were rich in minerals like magnesium, phosphorus, zinc and manganese.

A study conducted by Oshodi and Adeladun (1993) on the proximate composition of three varieties of lima bean with and without hull indicated a high protein content (21.8-26.2%) depending on the variety and whether the sample was dehulled. Rosaiah *et al.* (1993) analysed nine varieties of mung bean and revealed that the protein content ranged from 20.5-25.9 per cent.

Siddhuraju *et al.* (1994) analysed the lesser known pulses like *Vigna aconitifolia* (Jacq.) and *Vigna vexillata* (L.) and found that both the pulses were rich in proteins and minerals.

Apata and Ologhobo (1994) studied two varieties each of bambara groundnut, kidney bean, lima bean, pigeon pea, and one variety of jack bean grown in Nigeria and found that the crude protein of all the legume seeds varied from 20.6-27.7 per cent; crude fibre 3.2-9.5 per cent; fat 1.3-6.7 per cent and ash 3-4.8 per cent. Potassium was the most abundant mineral present in these beans. According to Parihar *et al.* (1994) the protein content of faba bean (*Vicia faba*) seeds varied between 26-28 per cent; crude fat 0.45-0.65 per cent and total carbohydrates 59-62 per cent.

Four varieties of kidney beans were evaluated for its nutrient contents by Sangha *et al.* (1994) and revealed that they were rich in protein (21.07-26.6%); calcium (145-157 mg/100 g) and iron (4.8-5.83 mg/100 g). Wild under-exploited edible legume seeds, *Cassia obtusifolia* and three germplasm of *Arbus precatorius* were evaluated by Mohan and Janardhanan (1995) for their proximate composition and minerals. They were found to contain crude proteins (16.1-22.8%), fat (8.8-12.7%) and carbohydrates (55.1-65.8%). Among the different minerals, potassium was found to be more predominant. Thirty two genotypes of green gram were studied by Kochhar and Hira (1997) and reported that the protein content of these varieties ranged between 18.12 and 26.87 per cent. Singh and Sood (1997) evaluated the proximate composition of French beans and found that they were rich in protein (20.65-22.75%), crude fibre (3.54-4.23%), fat (1.54-1.63%), carbohydrate (57.7-59.7%) and energy (376-379 K cal/100 g).

According to Naik (1997) soybean ranks highest among the pulses for having maximum calories (432 K cal); protein (43.2%); iron (10.4 mg %) and minerals (4.6 %). The amino acid make up of soybean is similar to that of cow's milk. The fatty acid composition indicated high unsaturated fats (86%).

According to Chimmad (1997) black bean contained a protein content of 29.33 per cent, while moth bean had a protein content of 23.6 per cent. The seeds of rice bean were rich in protein (25.8%) and contained appreciable amounts of limiting amino acids tryptophan and methionine.

2.4 Nutritional composition of winged bean

The places of the origin of winged bean is a subject of speculation. The house of winged bean according to Burkhill (1935) is either in Madagascar or Mauritius. Cobley (1956) claims India as the centre of origin. However, NAS (1975a) mentioned Papua New Guinea as the primary centre of origin of winged bean, based on the extent of variability present and on the knowledge of cultivation of the crop since time immemorial and considering the favourable climatic conditions optimum for its growth. Hymowitz and Boyd (1977) also opined Papua New Guinea as the place of origin of winged bean. According to Chandel *et al.* (1979) winged bean was introduced to India in 1799.

Winged bean is a crop which received considerable acclaim because of its high protein content (Claydon, 1975). Cerny and Addy (1973) reported that processed mature seeds of winged bean when fed to children suffering from kwashiorkor compared well with the results obtained from maize and skimmed milk powder. The winged bean has aroused great interest as an excepionally prospective legume suitable for meeting protein needs in areas of food scarcity and wide spread malnutrition (NAS, 1981). Cerny *et al.* (1981) suggests that winged bean seed could be successfully used as a source of protein in weaning diets. According to Nath *et al.* (1994) the entire winged bean plant, ie. the tender leaves, flowers, green pods, mature seeds and tubers are edible.

Winged bean seeds are similar to soybean in composition (NAS, 1975a; Gillespie and Blagrove, 1978). Winged bean can be said to be virtually a duplicate of soybean in composition and nutritive value, both contain similar proportions of protein, oil, minerals, vitamins, essential amino acids and other constituents (NAS, 1975a and Janoria *et al.*, 1984).

NAS (1975a) reported that the moisture content in immature pods and leaves of winged bean ranged from 76 to 92 per cent and 64.2 to 77.7 per cent, respectively. Tubers contained a higher percentage of moisture ranging from 54.9-65.2 per cent while the seeds contained only 6.7-24.6 per cent. Moisture content in the winged bean seeds grown in the highlands of Papua New Guinea was reported as 11.6 per cent by Jaffe and Korte (1976).

According to Norgan *et al.* (1979) a moisture content of 60 per cent was found in roots while immature pods had 87 per cent moisture and beans had 70.6 per cent moisture. Garcia and Palmer (1980) and Ekpenyong (1985) reported a moisture content of 10.4 per cent in the seeds of winged bean. Kailasapathy and Nagalingam (1986) reported the moisture content of winged bean seeds as 10.3-54.2 per cent while the tubers contained 55 per cent.

Winged bean seeds contained about 34 per cent protein and 17 per cent oil. The nutritional quality of the protein was comparable to that of soybean. The protein content of immature pods have been reported to range from 1.9-2.9 per cent;

seeds 29.8-37.4 per cent; tubers 12.2-15.0 per cent; flowers 5.6 per cent and the leaves 5.7-15.0 per cent (NAS, 1975a).

According to NAS (1975a) and Ekpenyong and Borchers (1982) the protein content of the edible tubers was much higher than the protein content of other edible roots and tubers like cassava (1%), potato (2%), sweet potato (2%) or yam (2%).

Winged bean from the highlands of Papua New Guinea contained a protein content of 30.6 per cent (Jaffe and Korte, 1976). The leaf protein content of winged bean introduced to Sri Lanka ranged from 24.48 to 31.46 per cent (Senanayake and Sumansingha, 1976). According to Kantha *et al.* (1978) the tuber protein contents ranged from 4.8-25.6 per cent while leaf protein ranged from 4.5-11.8 per cent.

A protein content of 6.4 per cent in roots, 3.2 per cent in immature pods and 8.1 per cent in beans was reported by Norgan *et al.* (1979). Rao and Belavady (1979) reported a high protein content in winged bean tubers with high lysine and methionine values. According to Hettiarachchy *et al.* (1979) the mean protein content of the seeds was 36.09 per cent. The protein content of fresh tubers ranged from 2.27 to 8.05 per cent while fresh leaves had a protein content of4.55 to 11.81 per cent. The protein content of fresh pods and flowers ranged from 1.31-2.73 per cent and 1.25-2.65 per cent respectively. Yap *et al.* (1980) studied the nutritive value of the different plant parts and observed that the crude protein content is highest in the seeds followed by young leaves, old leaves, green pods and tubers.

Okezie and Martin (1980) reported high lysine, tryptophan, aspartic acid, glutamic acid and leucine levels in seeds, seed hulls and leaves of winged bean.

Kantha and Hettiarachchy (1981) determined the protein content of seeds, tubers, pods, leaves and flowers of winged bean and reported that the protein content in seeds was 29.8-42.9 per cent; leaves 4.6-11.8 per cent; flowers 1.1-2.7 per cent; immature pods 1.3-2.7 per cent and tubers 2.3-8.1 per cent. The seed flour was found to be rich in lysine.

According to Ekpenyong and Borchers (1982) the protein content in seeds is similar to that in soybean (35.9 g/100 g edible portion of dry seed). Amino acid composition of the different parts indicated high amounts of lysine and threonine with total essential amino acids similar or superior to that of soybean.

The crude protein in tubers was reported to be between 5.7-6.7 per cent on fresh weight basis by Poulter (1982). Amino acid composition revealed that they contained an exceptionally high amount of aspartic acid. Janoria *et al.* (1984) reported a protein content of 36.4 per cent in the seeds of winged bean while that of jack bean had 30 per cent and *Cicer arietinum* had 19.4 per cent.

Kantha *et al.* (1986) reported the seeds to be rich in protein with a crude protein range of 27.8 to 47.2 per cent in different varieties of winged bean. In a study by Prakash *et al.* (1987) the crude protein content of winged bean seeds ranged from 38.1 to 45.0 per cent.

According to Hemalatha and Poddar (1995) the mature dry seeds are the most nutritious part of winged bean. The high protein content (30-40%) and their favourable amino acid compostion makes it a nutritious bean.

The fat content of immature pods ranged from 0.2-0.3 per cent and the fat content of seeds and tubers were 15.0-20.4 per cent and 0.5-1.1 per cent respectively. Of the fatty acids in the oil, 71 per cent were unsaturated (NAS, 1975a). Hettiarachchy *et al.* (1979) reported a mean oil content of 17.81 per cent in the seeds of winged bean. According to the authors oleic and linoleic acids formed the major fatty acid components of the oil and hence winged bean seeds could be used to reduce the blood cholesterol level.

Kantha and Hettiarachchy (1981) reported an oil content of 11.0-23.0 per cent in the seeds of winged bean of which oleic acid formed 40.2 per cent and linoleic acid formed 31.6 per cent; while Murugiswamy *et al.* (1983) reported 14.4 per cent oil in the winged bean seeds. According to Janoria *et al.* (1984) the oil content of *Psophocarpus tetragonolobus* is 18.8 per cent. According to Banerjee (1985) the fat content of winged bean leaves ranged from 5.04-6.85 per cent, while the fat content of tubers ranged between 0.3-0.5 per cent. Kailasapathy and Nagalingam (1986) reported a fat content of 19 per cent in the seeds. Misra *et al.* (1987) revealed that the fat content in 34 cultivars of winged bean varied from 14.1-17.6 per cent.

The carbohydrate content of immature pods was reported to range from 3.1-3.8 per cent while in seeds and tubers it ranged from 27-32 per cent (NAS, 1975a). According to Norgan *et al.* (1979) the carbohydrate content of immature pods, beans and roots was 6.5 per cent, 12.9 per cent and 25.4 per cent, respectively. A total of 25-45 per cent carbohydrate was reported in winged bean seeds by Kadam *et al.* (1981). Poulter (1982) reported starch as the major carbohydrate present in the flesh of fresh roots (21.7-32.1%). Lower concentrations of starch (7.9-10%) had been reported by Ibuki *et al.* (1983).

Misra and Misra (1985) reported a carbohydrate content of 30.71 per cent in whole seeds and 41.05 per cent in defatted flour. According to Ekpenyong

(1985) the carbohydrate content in seeds was 23.9 per cent. Kantha *et al.* (1986) reported the carbohydrate content of seeds to range between 26.2 and 35.5 per cent.

The fibre content in immature pods, seeds and tubers ranged from 1.2-2.6 per cent; 5.0-12.5 per cent and 17.0 per cent respectively (NAS, 1975a). The fibre content in winged bean seeds was reported as 9.4 per cent by Jaffe and Korte (1976). Analysis of edible portions of winged bean roots, young pods and beans by Norgan *et al.* (1979) revealed a fibre content of 6.5 per cent in roots, 1.6 per cent in immature pods and 1.9 per cent in beans.

Garcia and Palmer (1980) reported the dietary fibre in winged bean seeds as 14 per cent which was concentrated in the hulls. Misra and Misra (1985) estimated the proximate composition of winged bean varieties grown in India and the fibre content in whole seed and defatted meal was reported as 12.7 per cent and 10 per cent respectively. Among the five legumes winged bean, rajmah, khesari dhal, soybean and bengal gram analysed for fibre components by Sharma (1986), winged bean was found to be the highest in fibre content (32.5%) followed by bengal gram (26%).

Janoria *et al.* (1984) reported the energy content of *Psophocarpus tetragonolobus* seeds as 450 K cal/100 g which is higher than that of most of the major and minor legumes like jack bean (393 K cal), sword bean (375 K cal), *Cicer arietinum* (396 K cal) and *Pisum sativum* (391 K cal).

Immature pods of winged bean contain 1.3-1.7 mg per cent of iron and 63-330 mg per cent of calcium. The calcium content of seeds is 204-307 mg per cent and iron content is 9.6-11.8 mg per cent. Tubers contain 40 mg per cent calcium and 3 mg per cent iron (NAS, 1975a).

According to Jaffe and Korte (1976) the calcium, phosphorus and iron contents in winged bean were 215 mg per cent, 500 mg per cent and 18 mg per cent, respectively. Okezie and Martin (1980) reported that the leaves contain higher amounts of iron, phosphorus, potassium and manganese than the seeds.

According to Ibuki *et al.* (1983)the seeds are high in phosphorus, calcium and magnesium [illegible] The calcium content in leaves was much higher than other parts. Janoria *et al.* (1984) reported a calcium content of 88 mg and iron content of 2.2 mg per 100 g in *Psophocarpus tetragonolobus* seeds.

Iguchi *et al.* (1987) evaluated the mineral content of immature winged bean pods. Mineral values as reported by the authors were calcium (33 mg/100 g); phosphorus (31 mg/100 g) and iron (0.6 mg/100 g). According to Rao (1997) the mature dry seed of winged bean is an excellent source of calcium and iron.

According to NAS (1975a) the immature pods of winged bean contained 22-37 mg/100 g of ascorbic acid and the seeds were rich in tocopherol. Jaffe and Korte (1976) reported that 100g of winged bean seeds grown in the highlands of Papua New Guinea contained thiamine (1.03 mg), riboflavin (0.33 mg) and niacin (3.09 mg). Rockland *et al.* (1979) reported that raw beans contained thiamine (0.69 mg %), riboflavin (0.36 mg %) and niacin (3.13 mg %) which was reduced to 0.12 mg %, 0.2 mg % and 0.72 mg % respectively during cooking.

2.5 Antinutritional factors in winged bean

Food legumes are important sources of dietary proteins in the developing countries, but their acceptability and utilization have been limited due to the presence of relatively high concentrations of certain antinutritional factors (Nowacki, 1980).

Legumes contain a wide range of toxic components : trypsin and chymotrypsin inhibitors, lectins or haemagglutinins, cyanogens, saponins and toxic amino acids. The amounts vary with species and variety, but in general, legumes tend to contain more toxic materials than cereals (NAS, 1975a; Salunkhe *et al.*, 1982). Phenolic compounds are present in the seed coat of grain legumes (Singh and Jambunathan, 1981). These antinutritional factors can affect the nutritional value of proteins (Chang and Satterlee, 1982; Dhurandhan and Chang, 1990).

Antinutritional factors are found in other groups of vegetables also. According to a report by NAS (1975b) fresh leaves of Chaya, an underexploited vegetable contained toxic hydrocyanic glycosides. Henderson *et al.* (1986) reported trypsin inhibitors, lectins, phytates and oligosaccharides in defatted, decorticated Cucurbita seed meals. Studies by Al-Khatani (1995) in *Moringa perigrina* products have shown higher levels of phytic acid and lower levels of a-amylase inhibitors.

Chavan and Hejgaard (1981) studied the comparitive activities of trypsin and chymotrypsin inhibitors in several legume seeds. The trypsin inhibitor and chymotrypsin inhibitor activities in pigeon pea was found to be higher than that of the seeds of cowpea, broad bean and lentil. Gad *et al.* (1982) analysed the oxalate content of six legumes and the highest amount was found in broad beans. Janoria *et al.* (1984) found trypsin inhibitors and toxic cyanogens in cowpea. The seed meal of Jack bean have been reported to contain thermolabile toxins like canavalin and canavanine. Sword bean contained toxic saponins and some amounts of hydrocyanic acid (Janoria *et al.*, 1984).

Mohan and Janardhanan (1995) reported the presence of antinutritional factors like total free phenols and tannins in the germplasm seeds of the tree legume *Arbus precatorius* and *Cassia obtusifolia*.

Studies by Chitra *et al.* (1995) on several genotypes of chickpea, pigeon pea, mung bean and soybean revealed the highest phytic acid content in soybean followed by pigeon pea, mung bean and chick pea. Soybean, eventhough rich in nutrient make-up, is known to contain several antinutrients. Presence of a variety of antinutrients such as enzymes, protease inhibitors, haemagglutinins, phytases, oligosaccharides, saponins, sterols, alcohols, goitrogens and phenolic compounds have been reported in soybeans (Naik, 1997).

Like soybeans, the seeds of winged bean contained compounds that interfere with protein digestion (NAS, 1975a). The dried seeds were found to contain powerful trypsin inhibitors (Hettiarachchy *et al.*, 1978). Adimorah (1979) reported toxic and pharmaceutically active constituents including agglutinating and anti-tryptic factors in the seeds and cyanide in the stems. Delumen and Salamat (1980) reported a tannin content of 1.58 μg/100 g in the winged bean seeds. According to Kute *et al.* (1984), the trypsin inhibitor activity increased with maturity of the seeds. Kadam and Salunkhe (1984) estimated the tannin content in the winged bean varieties grown in Srilanka and Nigeria and reported the values as 1.3 per cent and 1.4 per cent, respectively. Kantha *et al.* (1986) reported the tannin content in different varieties of winged bean, the range was 0.02 to 0.07 per cent.

Singh *et al.* (1987) reported the specific haemagglutinating activity, trypsin inhibitor and saponin content of winged bean seed as 3.92 Hua/g sample, 1317.20 and 92.91 mg/g respectively. Feeding of raw winged bean to growing albino rats caused the cessation of growth accompanied by decreased food intake.

Misra *et al.* (1987) analysed 34 cultivars of winged bean and found that the trypsin inhibitor activity varied from 63 to 123 mg/g with seed coat and 51 to 98 mg/g without seed coat. Kotaru *et al.* (1987) reported the antinutritional factors in 12 varieties of winged bean : tannin ranged from 1.3 to 6.75 mg/ g sample, phytic acid from 7.7 to total phosphorus, chymotrypsin inhibitory activity was about double to that of trypsin inhibitory activity, but α-amylase inhibitory activity could not be detected in any of the winged bean varieties used in the study.

Harder (1994) reported accumulation of aluminium in the edible parts of the winged bean plant. Field experiments showed that all edible portions accumulated aluminium from high to very high levels when compared with that of other crop plants.

Inspite of the presence of toxins, legumes can be safely eaten, provided they are adequately prepared (NAS, 1975a). Toxic factors present in winged bean seeds may be safely destroyed by normal cooking and processing as with other legumes (Claydon, 1978). According to Sathe and Salunkhe (1981) the tannins in the seeds could be decreased by removing the seed coat or soaking in 2 per cent potassium hydroxide. Soaking beans in alkali inactivated haemagglutinating activity and reduced trypsin inhibitor activity.

Rao and Deosthale (1982) reported that decortication of pulses resulted in 83-97 per cent loss of tannin and by soaking in water 50 per cent of the tannin was lost in pigeon pea and chick pea. According to Tan and Wong (1982) prolonged cooking of the seeds of winged bean was necessary to reduce the trypsin inhibitor activity subsequently. Gad *et al.* (1982) opined that steeping and sprouting of the seeds reduced the phytic acid contents.

Ologhobo and Fetuga (1984) reported that trypsin inhibitor and haemagglutinin activities were completely inactivated by cooking and autoclaving while tannic acid and phytic acid contents were only partially affected. Cooking reduced tannic acid contents by 31-47 per cent. Soaking for 3 days decreased trypsin inhibitory activity by 31 per cent, haemagglutinin activity by 19 per cent tannic acid by 13.4 per cent and phytic acid by 24 per cent.

According to Tan *et al.* (1984) the chymotrypsin inhibitory activity of winged bean meal was extremely resistant to dry heat treatments and prolonged boiling was required to destroy the inhibitor activity. Autoclaving was found to be more effective in destroying the chymotrypsin inhibitor activity.

Significant decreases in the polyphenol content due soaking in water of mung bean (Barroga *et al.*, 1985) and winged bean (Sathe and Salunkhe, 1981; King and Puwastein, 1984) have also been reported.

Antinutritional factors such as trypsin and chymotrypsin inhibitors, phytates and phenols present in the dry seeds of moth bean could be destroyed to a great extent by domestic processing such as roasting, sprouting, boiling etc. (Khokhar and Chauhan, 1986). Esaka *et al.* (1987) showed that lipoxygenase and trypsin inhibitors in dry whole winged bean seeds were completely inactivated after microwave heating for 3.0 and 5.0 minutes respectively.

Levels of polyphenols in legumes can be reduced by simple processing methods such as soaking, dehulling and roasting (Rao and Deosthale, 1982; Jood *et al.*, 1987).

According to Kadam *et al.* (1987) substantial amounts of tannins, phytates, protease inhibitors, haemagglutinins and saponins were eliminated by processing the pulses. Verma and Mehta (1988) opined that the antinutrients like phytates, phenols, protease inhibitors and lectins present in rice bean were reduced by common processing techniques. Barampama and Simard (1994) suggested soaking, cooking or a combination of both as methods for decreasing the antinutritional factors in dry beans. Vijayakumari *et al.* (1995) reported that phenols, phytates, lectins and protease inhibitors present in the hyacinth bean could be reduced by processing.

2.6 Acceptability of the different edible parts of winged bean

It has been recognised that enjoyment of food is essential for good health. Enjoyment would mean choice and acceptance and not always nutrition and wholesomeness (Solms and Hall, 1981). Measuring the sensory properties and determining the importance of these properties as a basis for predicting acceptance by the consumer, represent major accomplishments for sensory evaluation (Bodyfelt *et al.*, 1988). For consumers, the perceivable sensory attributes like colour, appearance, feel, aroma, taste and texture are the deciding factors in food acceptance ([illegible] Pal *et al.*, 1995). According to Yenigi [illegible] (1997) sensory methods are used to evaluate the quality of food as well as to determine consumer preferences among food items.

The winged bean is most commonly used as a green vegetable, harvested when the pods are about half grown. The tender leaves, flowers, seeds and tubers as well can be consumed (NAS, 1975a).

Immature pods which can be eaten raw are highly palatable, taste like green beans and seem to be readily accepted even by those who have not previously eaten them (NAS, 1975a). In Thailand, Malaysia and other countries of South East Asia, winged bean pods are eaten as a cooked vegetable. The young green pods make a tender, crunchy vegetable that is eaten raw or added to cooked vegetable dishes. In Burma, the pods dipped briefly in boiling water are commonly eaten as a snack in the early afternoon (NAS, 1975a). According to Siiarma (1994) the fried, sliced or whole green pods are used by South Indians to prepare sambhar. It can also be used in soups and curries.

NAS (1975a) reported that the immature tuberous roots of winged bean are eaten like potatoes and taste like apple. In Burma, the tubers are boiled and eaten like potatoes with a sauce made from vegetable oil and salt. In Papua New Guinea the tubers are wrapped in banana leaves or in bamboo and cooked in a large earth-oven or in a fire. Martin and Delpin (1978) suggested that the cooked tuber may be mashed and sieved if excess fibre is present. The tubers are agreeable in flavour to young and old and can be used as a baby food. According to Hemalatha and Poddar (1995) the tubers of winged bean can be boiled, steamed, fried and baked. It can be used as a snack by making chips.

The leaves and flowers of winged bean may be eaten either raw or cooked; the flowers are added to salads. In Burma, salads are made from leaves that has been boiled briefly; the leaves are also added to fish and prawn soups. In the highlands of Papua New Guinea the flowers are fried in oil and they taste like mushrooms (NAS, 1975a). Martin and Delpin (1978) reported winged bean leaf as a spinach like vegetable. Leaves can be best prepared by frying or steaming with batter. According to Hemalatha and Poddar (1995) young leaves and flowers of winged bean are sometimes eaten raw or steamed or added to soups. Flowers of winged bean have a sweet taste as they contain nectar. When fried or steamed, they look like mushrooms. They also make an attractive garnish.

Mature seeds of winged bean are not eaten raw. They require cooking for 2-3 hours. Sometimes they are roasted and eaten like peanuts (NAS, 1975a). According to Martin and Delpin (1978), the dried seeds can be stored for long periods under cool, dry conditions. The seeds are seldom boiled. They soften slowly in water and sometimes require days to swell. Ripe seeds are sometimes roasted. The best product is obtained by soaking and softening the seeds first and then roasting them. The roasted seeds may be ground into a meal as a cereal. Ruberte and Martin (1979) have reported a nut like flavour in boiled winged bean seeds.

In addition to the consumption of boiled legumes, the roasted legumes also form popular snack items, which are liked by all (Khan, 1991; Kadam and Chavan, 1991).

According to Siiarma (1994) the seeds can be crushed into flour to prepare chapathies. Hemalatha and Poddar (1995) opined that the seeds could be steamed, boiled, fried, roasted, fermented or made into tofu (bean curd) or temph. The authors also reported that the flour made from the seeds can be used as a milk-substitute for children suffering from kwashiorkor.

Gwanfobe *et al.* (1991) conducted studies to find out the acceptability of different oil seeds like winged beans, groundnut, egusi and soybean among the tribal population of Cameroon. It was found that the sauces made from bitter leaves were most acceptable when supplemented with winged bean or egusi. Sauces made with huckleberry leaves had the highest scores when winged bean or soybean were used as supplements. Cassava leaf sauces had the highest score when winged bean was used as the oil seed.

2.7 Cooking qualities of the winged bean

Whole legumes with intact hulls take a long time to cook to a soft consistency. The seeds of winged bean have a particularly tough seed-coat (NAS, 1975a). Though high in protein, the seeds of winged bean are hard and bitter even after cooking. Their ability to imbibe water is variable and depends on soaking time, age, conditions and variety of the seed (Martin, 1978). According to Bressani and Elias (1979) the shorter the time required to make the beans soft, the higher is their acceptability. Ruberte and Martin (1979) reported that the seeds left to soak absorbed water slowly and took 3 or 4 hours for cooking. Ekpenyong and Borchers (1979) opined that soaking of seeds in water, prior to cooking improved their digestibility.

According to Kon and Sanshuck (1981) storage of dry beans under conditions of relatively high moisture and temperature increased the cooking time of the beans about five fold. Hettiarachchy and Kantha (1981) suggested that soaking of seeds for 6-8 hours made removal of the seed coat easier. Overnight soaking in sodium bicarbonate or in 0.5 per cent sodium chloride reduced the cooking time by half.

Narayan (1981) studied the cooking characteristics of winged bean dhal. Ammonium carbonate (0.5%) with either sodium carbonate or sodium bicarbonate

(0.5%) reduced the cooking time by nearly 50 per cent. According to Kailasapathy *et al.* (1985) soaking of seeds in 0.5 or 1 per cent sodium bicarbonate solution and boiling for 35-45 minutes was a suitable process for hull removal. The effects of soaking and boiling the seeds of winged bean were examined by Sambudi and Buckle (1991). It was found that soaking and/or boiling reduced the hardness of beans and increased the water absorption.

Material and Methods

MATERIALS AND METHODS

This chapter deals with the methods and procedures followed in the study and they are given under the following heads.

1. Field culture
2. Collection of samples
3. Chemical composition
4. Acceptability studies

3.1 Field culture

The crop was raised in the vegetable field of the Department of Olericulture, College of Horticulture, Vellanikkara as per the Package of Practices Recommendations of the Kerala Agricultural University (KAU, 1987).

3.1.1 Selection of the genotypes

The genotypes selected for the study were PT-92, PT-52, PT-82, PT-50-1 and PT-98. The 52 genotypes maintained in the Department of Olericulture, College of Horticulture were classified into five groups based on their mean yields for the years 1993 and 1994. One genotype was selected randomly from each group. Thus a total of 5 genotypes was selected for the study.

3.1.2 Preparation of the land

The land was prepared by digging followed by levelling. Pits of 60 cm depth and 60 cm diameter were made at a spacing of 2 m x 2 m. Farm yard manure at the rate of 20 tonnes ha^{-1} was applied basally in the pits. NPK at the rate of 50:100:50 kg ha^{-1} was also given. Full phosphorous and half of nitrogen and potassium were given as the basal dose.

3.1.3 Cultivation of winged bean

The seeds were sown 2-5 cm deep at the rate of 5 seeds of the same variety in a pit. Sowing of the seeds was done at the end of July. The seeds germinated and started growing after 9-10 days of sowing. Gap filling and thinning of seedlings were done so as to retain 3 seedlings in a pit.

The plants were staked and the vines were trailed. Top dressing with the remaining fertilizers, i.e., half of nitrogen and potassium was done one month after sowing. Irrigation was also given once in three days during the dry periods.

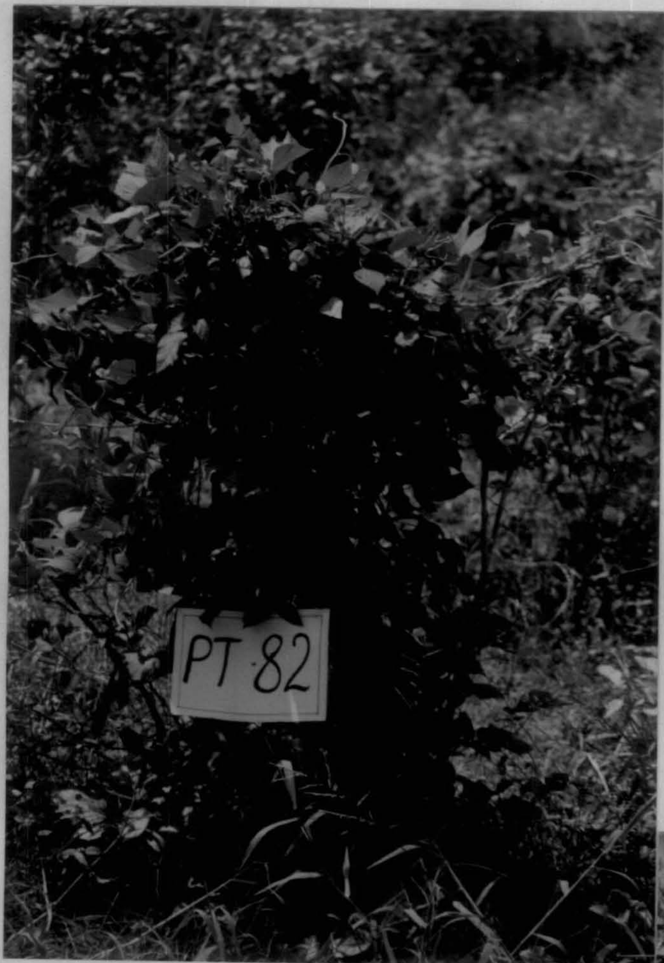
The fully grown plants of the five genotypes are presented in the Plates 1 to 5. Plate 6 shows the winged bean flower and Plate 7 shows the winged bean pod.

3.2 Collection of samples

Flowering started 50-60 days after sowing. Flowers belonging to the same genotype were collected randomly in the morning after 10 o'clock. Tender leaves were collected from plants belonging to the same genotype. The pods of 12-14 days maturity were collected randomly from plants belonging to the same genotype. Some of the pods were left to mature on the plant for seeds. The pods became fully mature and dry after a period of 25-30 days and the dry pods were harvested and the seeds were collected by pressing the pods.

Plate 1. Fully grown plant of the winged bean genotype PT-82

Plate 2. Fully grown plant of the winged bean genotype PT-52


PT-82


PT-52

Plate 3. Fully grown plant of the winged bean genotype PT-92

Plate 4. Fully grown plant of the winged bean genotype PT-50-1


PT-92


PT-50-1

Plate 5. Fully grown plant of the winged bean genotype PT-98


PT-98

Plate 6. Winged bean flowers

Plate 7. Winged bean pod

3.3 Chemical composition of the different plant parts

3.3.1 Analysis of nutrients

The edible portions of the 5 winged bean genotypes i.e. flowers, leaves, pods and seeds were analysed for the following nutrients.

1. Moisture
2. Protein
3. Fat
4. Starch
5. Fibre
6. Energy
7. Calcium
8. Iron and
9. Vitamin C.

The analysis of moisture and ascorbic acid contents of the different plant parts was done immediately after harvesting. The different plant parts were chopped and dried in a hot-air oven at a temperature of 110°C for 72 hours, powdered and stored in containers for further chemical analysis. The protein, fat, starch, fibre, energy, calcium and iron contents of the dried sampleswere estimated.

The moisture content of the selected plant parts was estimated using the A.O.A.C. method (1980).

The protein content of the different plant parts was estimated using the Microkjeldkal Method (A.O.A.C., 1965).

The fat content of the different plant parts was estimated using the A.O.A.C. method (1955).

The starch content in the different plant parts was estimated using the procedure as suggested by Sadasivam and Manikam (1992).

Crude fibre content of the dried samples was estimated by acid-alkali digestion methods as suggested by Chopra and Kanwar (1978).

The energy content of the selected plant parts was estimated using Bomb Calorimeter.

For estimating the calcium and iron contents of the different parts of winged beans, a diacid extract of the sample was prepared and was estimated in an Atomic Absorption Spectrophotometer (Perkin-Elmer, 1982).

The ascorbic acid contents of the different edible parts of winged bean was estimated by the method of A.O.A.C. (1955) using 2,6 dichloroindophenol dye.

3.3.2 Estimation of tannin

The tannin content of the raw seeds of winged bean was analysed using A.O.A.C. (1970) method.

All the analyses were conducted in triplicate samples. The seeds of winged bean were soaked for 12 hours in water and cooked under pressure for 30 minutes. The tannin content of the cooked seeds was analysed using the A.O.A.C. (1970) method.

3.4 Acceptability of the different edible parts of winged bean

Acceptability trials of the different plant parts i.e., flowers, leaves, pods and seeds of the five selected genotypes was conduced at the laboratory level.

3.4.1 Selection of judges

A series of acceptability trials were carried out using simple triangle tests at the laboratory level to select a panel of 10 judges from a group of 25 healthy women between the age of 18-35 years (Jellinek, 1985).

3.4.2 Preparation of the edible parts for acceptability studies

The plant parts except the mature dry seeds were washed thoroughly in water to remove the adhering dirt and cut into small pieces using a stainless steel knife. A mixture of ground coconut, onions, chillies and turmeric powder was made. Five tablespoon full of the plant part was sauted in oil. Leaves and flowers were sauted for 5 minutes and 2 tablespoon full of the ground coconut mixture was added. A little salt was added and cooked. The pods were sauted for 10 minutes to become tender. The seeds were soaked overnight and pressure cooked for 30 minutes before sauting.

3.4.3 Organoleptic evaluation of the different edible parts of winged bean

Acceptability trials of the winged bean parts was conducted using the scoring method (Swaminathan, 1974). The score card developed for the study is presented in Appendix-I. Five quality attributes like colour, texture, doneness, taste and flavour were included as the quality attributes. Each of the above mentioned quality was assessed by a five point hedonic scale.

The judges were requested to taste one sample and score it. They were requested to taste the second sample after washing their mouth. Each quality attribute was assessed by the panel members after testing the same samples several times if needed. The panel members were permitted to take their own time and to judge the samples leisurely.

The testing was done in the afternoon between 3 pm and 4 pm, since this time is considered as the ideal time for conducting the acceptability studies (Swaminathan, 1974).

Results

RESULTS

The results pertaining to the study entitled "Nutritive value and acceptability of winged bean genotypes are presented under the following headings.

1. Physical features of winged bean genotypes
2. Composition of winged bean genotypes
3. Organoleptic qualities of winged bean genotypes

4.1 Physical features of winged bean genotypes

The common physical features of the winged bean like stem colours, leaflet shape, flower colour, pod size, pod colour, seed colour and seed size were recorded and the results are presented in Table 1.

Table1. Physical features of winged bean genotypes

Characteristic	Variety				
	PT-92	PT-98	PT-52	PT-50-1	PT-82
Stem colour	Green	Green	Green	Green	Green
Leaflet shape	Cordate	Cordate	Cordate	Cordate	Cordate
Flower colour	Purple	Blue	Blue	Blue	Purple
Pod size	Medium	Medium	Medium	Long	Medium
Pod colour	Green	Green with brown spots	Green	Green	Green
Seed colour	Light brown	Black	Black	Light brown	Brown
Seed size	Medium	Large	Large	Medium	Medium

The stem colour in all the five genotypes was found to be green and the leaflet shape was cordate in all the genotypes. The flower colour was blue in all the genotypes except PT-92 and PT-82 in which the flowers were purple. The pod size was medium in all the genotypes except PT-50-1 which had long pods. The pods of all the genotypes except PT-98 had green colour in which the green coloured pods had brown spots on the wings. Seeds of the two genotypes PT-98 and PT-52 had black colour while the seeds of PT-92 and PT-50-1 were light brown in colour and the seeds of PT-82 were brown coloured. The seeds of the genotypes namely PT-92, PT-50-1 and PT-82 were medium sized while the seeds of PT-98 and PT-52 were large sized.

4.2 Composition of winged bean genotypes

4.2.1 Moisture

The moisture content of the leaves, flowers, pods and seeds of the five winged bean genotypes are given in Table 2. The results of statistical analysis are presented in Table 3.

The moisture content of the leaves ranged from 59 to 61.1 per cent with a mean value of 59.8 per cent. Statistical analysis revealed that the moisture content of the five winged bean genotypes was significant at five per cent level. The highest moisture content was found in PT-52 and the lowest in PT-98.

In flowers, the moisture content ranged from 67.6-71.4 per cent with a mean value of 70.14 per cent. There was significant variation in the moisture content of the flowers between the different genotypes at 1 per cent level with PT-98 having the highest moisture content and PT-50-1 having the lowest moisture content.

The pods had a moisture content ranging between 70.3 per cent (PT-82) and 74.6 per cent (PT-98) and the variations between the diferent genotypes was found to be statistically significant at 1 per cent level. The average moisture content of the pod was found to be 71.54 per cent.

The moisture content of the seeds of the five genotypes ranged from 6.1 to 9.9 per cent with a mean value of 7.96 per cent. The variation between the five genotypes was found to be statistically significant at 1 per cent level and the highest moisture content was found in PT-82 while PT-52 had the lowest moisture content.

From Table 1 it is clear that among the different parts analysed, the pods had the maximum moisture content. The lowest moisture content was present in dry seeds among all the five genotypes. A comparison of the moisture content of the edible parts of winged bean genotypes is presented in Fig.1.

Table 2. Moisture content of the edible parts of winged bean genotypes (g/100 g)

Genotype	Plant part			
	Leaves	Flowers	Pods	Seeds
PT-98	59.0	71.4	74.6	7.9
PT-82	59.4	70.4	70.3	9.9
PT-52	61.1	70.4	72.0	6.1
PT-92	59.9	70.9	70.4	8.2
PT-50-1	59.7	67.6	70.4	7.7
Mean	59.8	70.14	71.54	7.96
CD	1.216	1.243	1.639	0.776

Fig.1. Mositure content of edible parts of winged bean genotypes

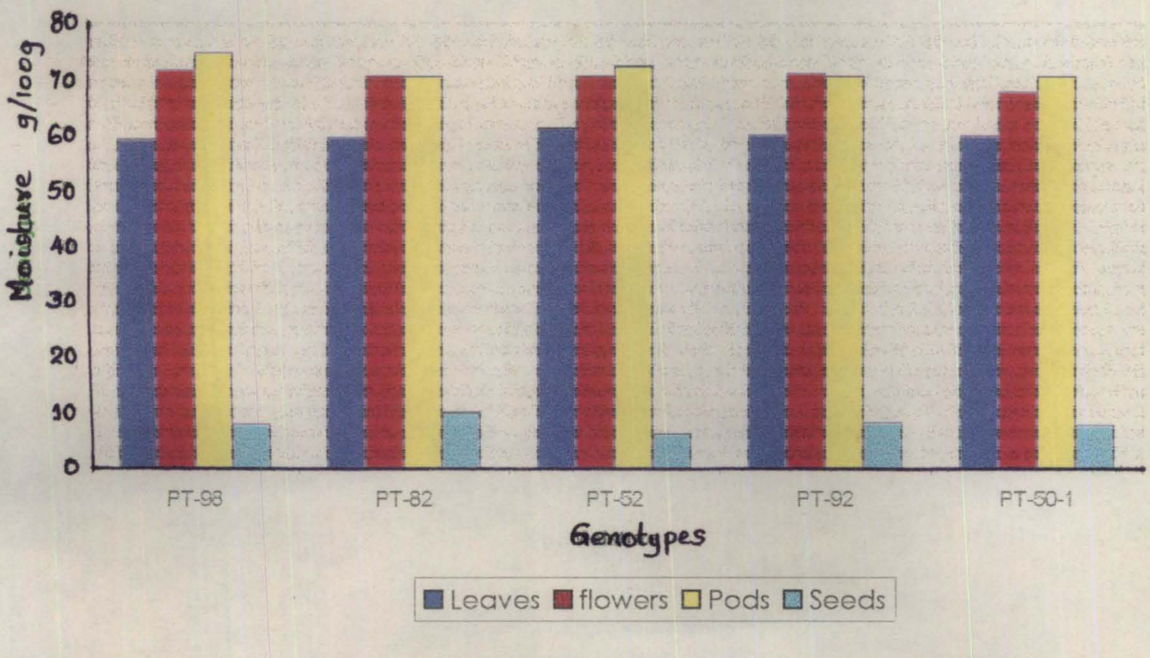


Table 3. Analysis of variance for moisture in the edible parts of winged bean genotypes

Genotype	DF	Mean sum of squares			
		Leaves	Flowers	Pods	Seeds
Variety	4	4.111	15.193	24.385	12.349
Error	30	1.244	1.301	2.260	0.507
F value		3.304*	11.676**	10.791**	24.338**

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

4.2.2 Protein

The crude protein content of the leaves, flowers, pods and seeds of the five genotypes of winged bean was analysed and the mean values are given in Table 4. The results of statistical analysis are depicted in Table 5. Among the different plant parts, seeds had the maximum protein which was very much higher than the protein content of leaves, flowers and pods.

The crude protein content of the leaves ranged from 3.0 to 4.0 per cent with a mean value of 3.24 per cent. Statistical analysis revealed that the variations in protein content between the different genotypes was significant at 1 per cent level.

The flowers had a protein content ranging from 2.6 to 3.1 per cent with the flowers of the genotype PT-92 having the maximum protein content and the flowers of the genotype PT-82 having the minimum protein. The mean protein content was found to be 2.92 per cent. From Table 5 it is clear that there was no significant variation in the protein content of the flowers between the different genotypes.

The protein content of the pods of the different genotypes of winged bean ranged from 2.7 to 3 per cent with a mean value of 2.9 per cent. The highest protein content was present in PT-98 and PT-52 and the lowest in PT-50-1. The variations in the protein content of the pods between the different genotypes was statistically not significant.

In seeds, the protein content ranged from 27.6 to 31.8 per cent with a mean protein content of 29.82 per cent. Statistical analysis showed that the variations in the protein content of the seeds between the different genotypes was statistically significant with the seeds of PT-82 having the highest protein content and the seeds of PT-98 having the lowest protein.

Among the different plant parts studied, the seeds of PT-82 had the maximum protein content (31.8%) and the lowest protein was present in the flowers of PT-82 (2.6%) (Fig.2). The results of statistical analysis showed that the protein content of the flowers and pods varied insignificantly between the different genotypes while there was significant variations in the protein content of the leaves and seeds between the different genotypes.

Table 4. Protein content of the edible parts of winged bean genotypes (g/100 g) (dry weight basis)

Genotype	Plant part			
	Leaves	Flowers	Pods	Seeds
PT-98	3.0	2.9	3.0	27.6
PT-82	3.0	2.6	2.9	31.8
PT-52	4.0	3.0	3.0	31.3
PT-92	3.2	3.1	2.9	30.2
PT-50-1	3.0	3.0	2.7	28.2
Mean	3.24	2.92	2.9	29.82
CD	0.484	NS	NS	1.292

Fig.2. Protein content of edible parts of winged bean genotypes (g/100g)

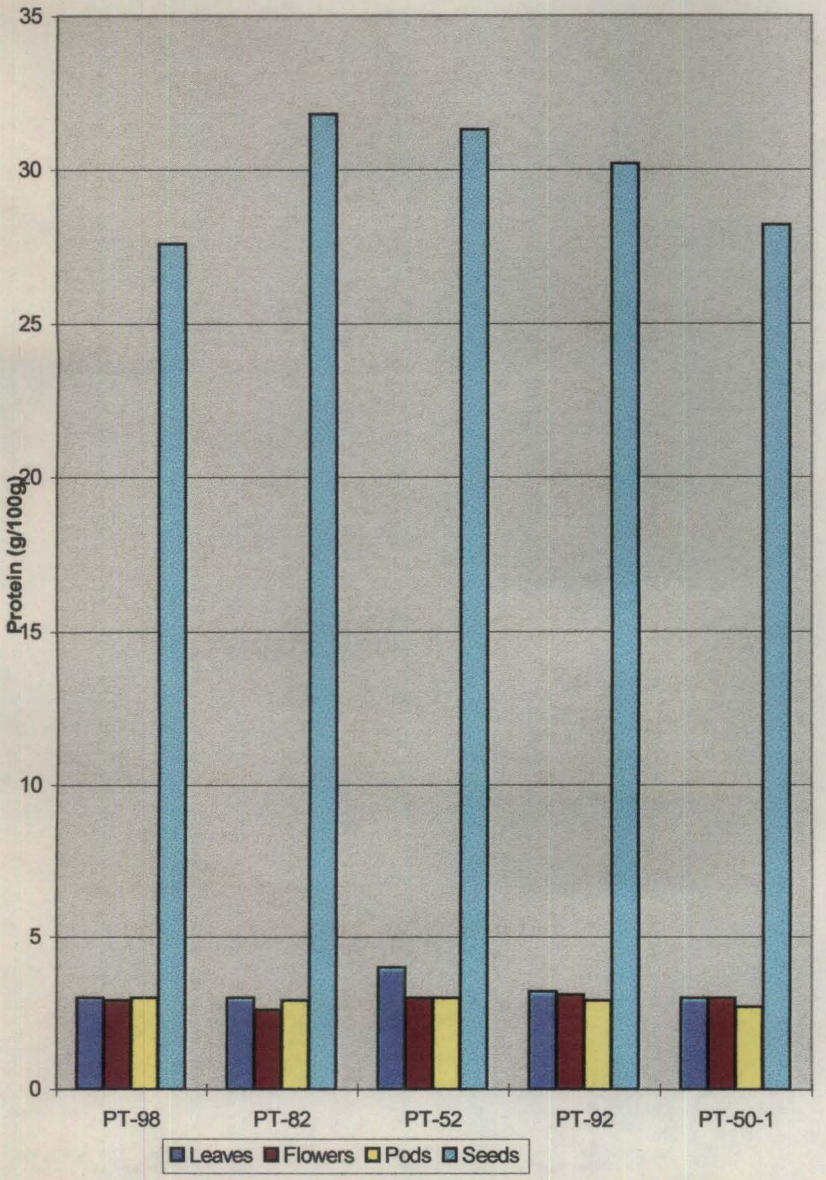


Table 5. Analysis of variance for protein in the edible parts of winged bean genotypes

Genotype	DF	Mean sum of squares			
		Leaves	Flowers	Pods	Seeds
Variety	4	1.233	0.234	0.119	23.998
Error	30	0.197	0.242	0.200	1.419
F value		6.259**	0.966	0.596	16.906**

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

4.2.3 Fat

The fat content of the leaves, flowers, immature pods and dry seeds of the different genotypes of winged bean are given in Table 6 and the results of the statistical analysis are presented in Table 7.

As revealed in Table 6, the fat content in the leaves of the different genotypes of winged bean ranged from 0.6 to 0.7 per cent with a mean value of 0.64 per cent and the variations between the different genotypes were statistically not significant. Among the five genotypes, three genotypes namely PT-98, PT-52 and PT-50-1 contained 0.6 per cent fat while the other genotypes contained 0.7 per cent fat.

The fat content of the flowers of the five winged bean genotypes ranged from 0.4 to 0.5 per cent with a mean fat content of 0.46 per cent. Statistical analysis showed that the variations in the fat content of the flowers between the different genotypes was not significant. The three genotypes namely PT-98, PT-52 and PT-92 had a fat content of 0.5 per cent while the other two genotypes had a fat content of 0.4 per cent.

The immature pods of the five genotypes of winged bean had a fat content ranging from 0.5 to 0.7 per cent with a mean fat content of 0.62 per cent. The variations in the fat content of the immature pods between the different genotypes were statistically significant. The genotypes PT-82 and PT-50-1 had the maximum fat content while the genotype PT-52 had the minimum fat content.

The dry seeds of all the five genotypes of winged beans were found to be rich in fat with the fat content in the seeds ranging from 16 to 18 per cent. The fat content in the dry seeds of the different genotypes varied significantly. The seeds of the genotype PT-52 had the maximum fat content while the seeds of the genotype PT-82 had the minimum fat content. The mean fat content was found to be 17.02 per cent.

Among the different plant parts studied, the dry seeds of all the genotypes had the highest fat content while the lowest fat content was seen in the flowers of the genotypes PT-82 and PT-50-1 (0.4%). The fat content of the different edible parts of winged bean genotypes are presented in Fig.3.

Table 6. Fat content of the edible parts of winged bean genotypes (g/100 g) (dry weight basis)

Genotype	Plant part			
	Leaves	Flowers	Pods	Seeds
PT-98	0.6	0.5	0.6	16.9
PT-82	0.7	0.4	0.7	16.0
PT-52	0.6	0.5	0.5	18.0
PT-92	0.7	0.5	0.6	17.5
PT-50-1	0.6	0.4	0.7	16.9
Mean	0.64	0.46	0.62	17.02
CD	NS	NS	0.109	0.545

Fig.3.Fat content of edible parts of winged bean genotypes (g/100g)

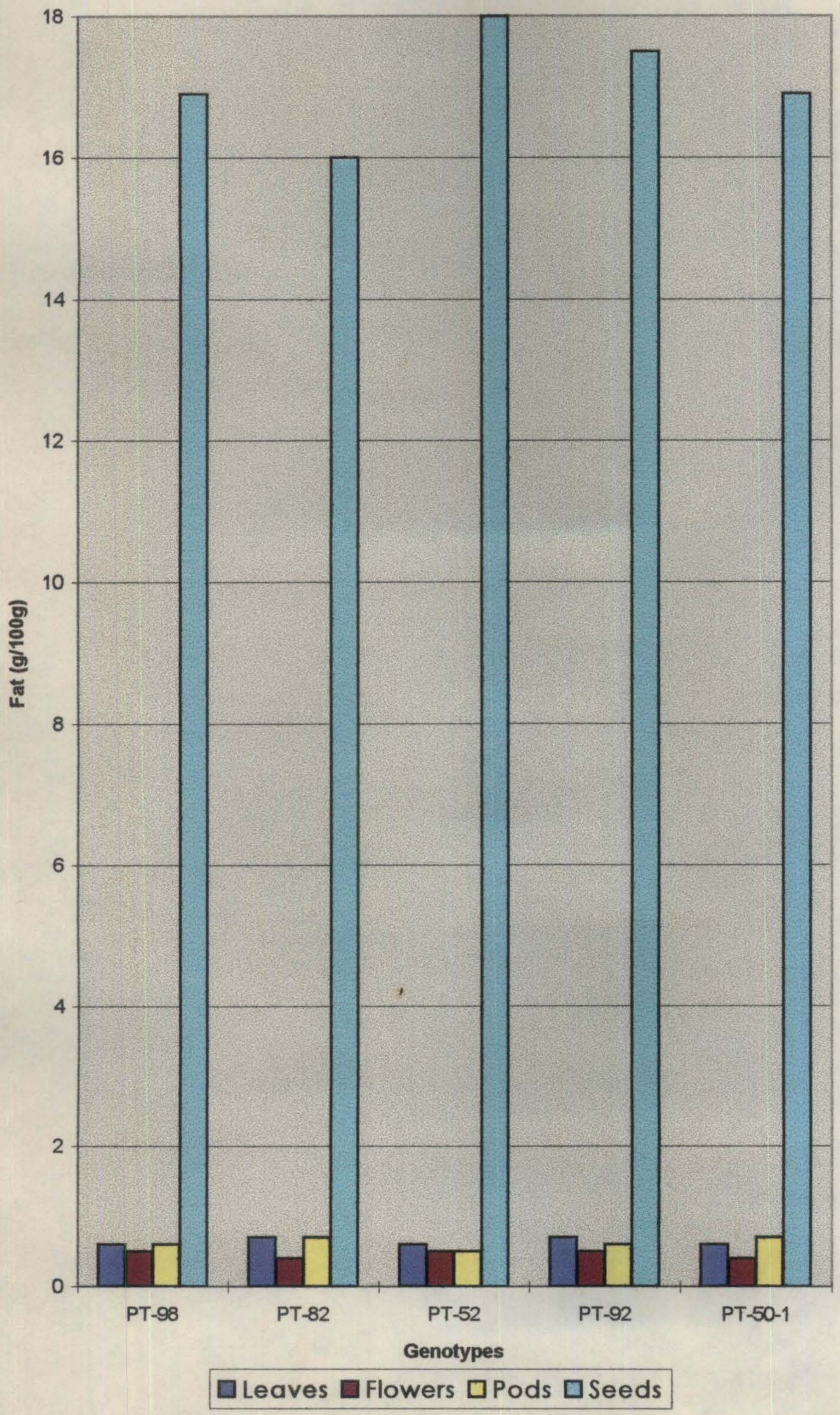


Table 7. Analysis of variance for fat in the edible parts of winged bean genotypes

Genotype	DF	Mean sum of squares			
		Leaves	Flowers	Pods	Seeds
Variety	4	0.019	0.014	0.048	3.892
Error	30	0.011	0.012	0.010	0.250
F value		1.769	1.205	4.805**	15.574**

** Significant at 1 per cent level

4.2.4 Starch

The starch content of the leaves, flowers, immature pods and dry seeds of the five genotypes of winged bean are presented in Table 8 and the results of statistical analysis are given in Table 9.

The starch content of the leaves ranged from 27.5 to 31.4 per cent with a mean value of 29.26 per cent. The variations in the starch content of the leaves between the different genotypes was statistically significant with the leaves of the genotype PT-92 having the highest starch content and the genotype PT-52 having the lowest starch content.

In flowers, the starch content ranged from 36.4 to 41.6 per cent with a mean value of 39.26 per cent. Variations in the starch content of the flowers between the different genotypes were found to be statistically significant. The flowers of the genotypes PT-92 had the highest starch content while the genotype PT-50-1 had the lowest starch content.

The starch content of the immature pods ranged from 23.6 to 27.5 per cent with a mean value of 25.32 per cent. Statistical analysis showed significant variations in the starch content of the pods between the different genotypes. Among the five genotypes, the pods of PT-52 had the highest starch content while PT-82 had the lowest starch content.

The dry seeds of all the five genotypes of winged bean were found to be high in starch content. The starch content of the dry seeds ranged from 47.1 to 51.2 per cent with a mean value of 49.16 per cent. There was significant variations in the starch content of the seeds between the different genotypes and the seeds of PT-52 had the highest starch content while the seeds of PT-92 had the lowest starch content.

As revealed in the table, among the different parts, seeds of all the genotypes had the highest starch content with a maximum of 51.2 per cent in PT-52 and a minimum of 23.6 per cent in PT-82. A comparison of the starch content of the different edible parts of winged bean genotypes is presented in Fig.4.

Table 8. Starch content of the edible parts of winged bean genotypes (g/100 g) (dry weight basis)

Genotype	Plant part			
	Leaves	Flowers	Pods	Seeds
PT-98	30.5	40.3	25.4	47.6
PT-82	28.6	37.2	23.6	49.6
PT-52	27.5	40.8	27.5	51.2
PT-92	31.4	41.6	25.6	47.1
PT-50-1	28.3	36.4	24.5	50.3
Mean	29.26	39.26	25.32	49.16
CD	0.331	0.483	0.249	0.357

Fig.4. Starch content of edible parts of winged bean genotypes

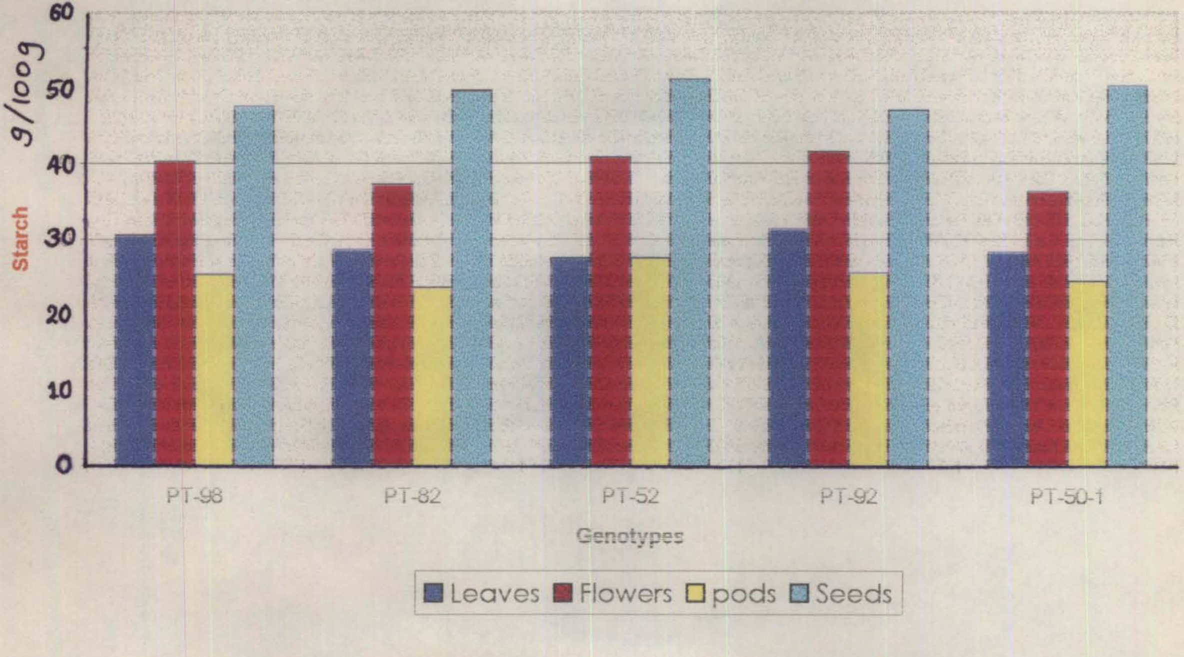


Table 9. Analysis of variance for starch in the edible parts of winged bean genotypes

Genotype	DF	Mean sum of squares			
		Leaves	Flowers	Pods	Seeds
Variety	4	18.095	37.035	14.461	21.579
Error	30	0.092	0.196	0.052	0.107
F value		196.707**	189.038**	278.717**	202.194**

** Significant at 1 per cent level

4.2.5 Fibre

The fibre content of the different edible parts - leaves, flowers, pods and seeds was analysed and the results are presented in Table 10 and the results of statistical analysis are presented in Table 11.

The leaves had a fibre content ranging from 16.8 to 19.4 per cent with a mean fibre content of 17.7 per cent. As revealed in Table 11, there was significant variations in the fibre content of the leaves between the different genotypes. Among the five genotypes, the leaves of PT-52 had the highest fibre content while the leaves of PT-92 had the lowest fibre content.

As shown in the table, the fibre content of the flowers ranged from 6.4 to 8.4 per cent. Statistical analysis showed that there was significant variations in the fibre content of the flowers between the different genotypes. The flowers of PT-52 had the highest fibre content while the flowers of PT-98 had the lowest fibre content. The mean fibre content of the flowers was found to be 7.04 per cent.

The fibre content of the pods was found to vary from 16.2 to 18.2 per cent with significant variations between the different genotypes. The mean fibre content of the pods was found to be 17.28 per cent. The pods of the genotype PT-52 had the highest fibre content while the pods of PT-82 had the lowest fibre content.

In the dry seeds of winged bean, the fibre content ranged from 10.4 to 10.9 per cent with a mean value of 10.58 per cent. There was no significant variation in the fibre content of the seeds between the different genotypes.

As revealed in Table 9 among the different plant parts the highest fibre content was present in the leaves with the leaves of the genotypes PT-52 having the maximum (19.4%). The pods of the different winged bean genotypes also were rich in fibre. The flowers of all the five genotypes had the lowest fibre content with the least value of 6.4 per cent for the genotype PT-98. A comparison of the fibre content between the different edible parts of the five genotypes is presented in Fig.5.

Table 10. Fibre content of the edible parts of winged bean genotypes (g/100 g) (dry weight basis)

Genotype	Plant part			
	Leaves	Flowers	Pods	Seeds
PT-98	18.5	6.4	17.0	10.9
PT-82	17.0	6.7	16.2	10.5
PT-52	19.4	8.4	18.2	10.4
PT-92	16.8	6.5	17.6	10.5
PT-50-1	16.9	7.2	17.4	10.6
Mean	17.72	7.04	17.28	10.58
CD	0.676	0.282	0.603	NS

Fig.5. Fibre content of edible parts of winged bean genotypes

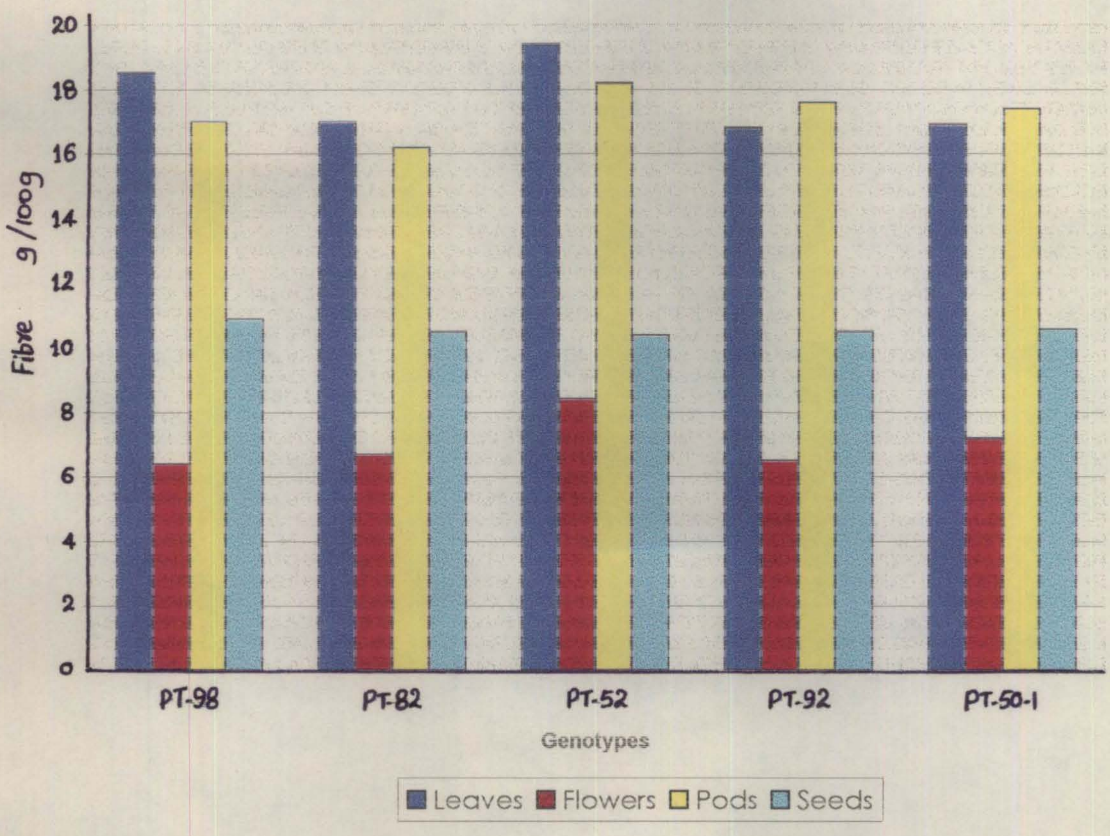


Table 11. Analysis of variance for fibre in the edible parts of winged bean genotypes

Genotype	DF	Mean sum of squares			
		Leaves	Flowers	Pods	Seeds
Variety	4	9.689	4.754	4.008	0.231
Error	30	0.385	0.067	0.306	0.592
F value		25.140**	70.842**	13.112**	0.391

** Significant at 1 per cent level

4.2.6 Energy

The calorific values of the different edible parts of winged bean genotypes were analysed and the results are presented in Table 12. The results of statistical analysis are given in Table 13.

As revealed in the table, the energy content of the leaves varied from 84-103 K cal/100 g with a mean value of 93.8 K cal/100 g. Among the different genotypes, the leaves of PT-92 contained the highest energy value while the lowest was present in PT-82. Statistical analysis indicate that there was no significant variation in the energy content of the leaves between the different genotypes.

In the case of flowers, the energy content ranged from 76-100 K cal/100 g. The mean energy value in flowers was found to be 87.6 K cal/100 g with the genotype PT-52 having the maximum energy content and the flowers of PT-82 having the minimum energy. The variations in energy content between the different genotypes was found to be statistically insignificant.

Among the immature pods, the genotype PT-92 had the highest energy value of 273 K cal/100 g and PT-82 had the lowest energy value of 95 K cal/100 g. The mean energy content of the pod was found to be 148.2 K cal/100 g. The difference in energy content of the immature pods between the different genotypes was found to be statistically significant.

The energy values of the dried seeds of winged bean ranged from 509-757 K cal/100 g with a mean value of 623.8 K cal/100 g. The variations in energy value of the seeds between the different genotypes was found to be statistically significant with the seeds of PT-92 having the highest energy content and the seeds of PT-82 having the lowest energy content.

As depicted in Fig.6, among the different edible parts, the seeds of all the five genotypes had the maximum energy value. The minimum energy content was found in the flowers of four genotypes except PT-52 in which the leaves had the lowest calorific value.

Table 12. Energy content of the edible parts of winged bean genotypes (K cal/100 g) (dry weight basis)

Genotype	Plant part			
	Leaves	Flowers	Pods	Seeds
PT-98	101	86	99	556
PT-82	84	76	95	509
PT-52	95	100	99	697
PT-92	103	97	273	757
PT-50-1	86	79	175	600
Mean	93.8	87.6	148.2	623.8
CD	NS	NS	57.7	64.2

Fig.6.Energy content of edible parts of winged bean genotypes (Kcal/100g)

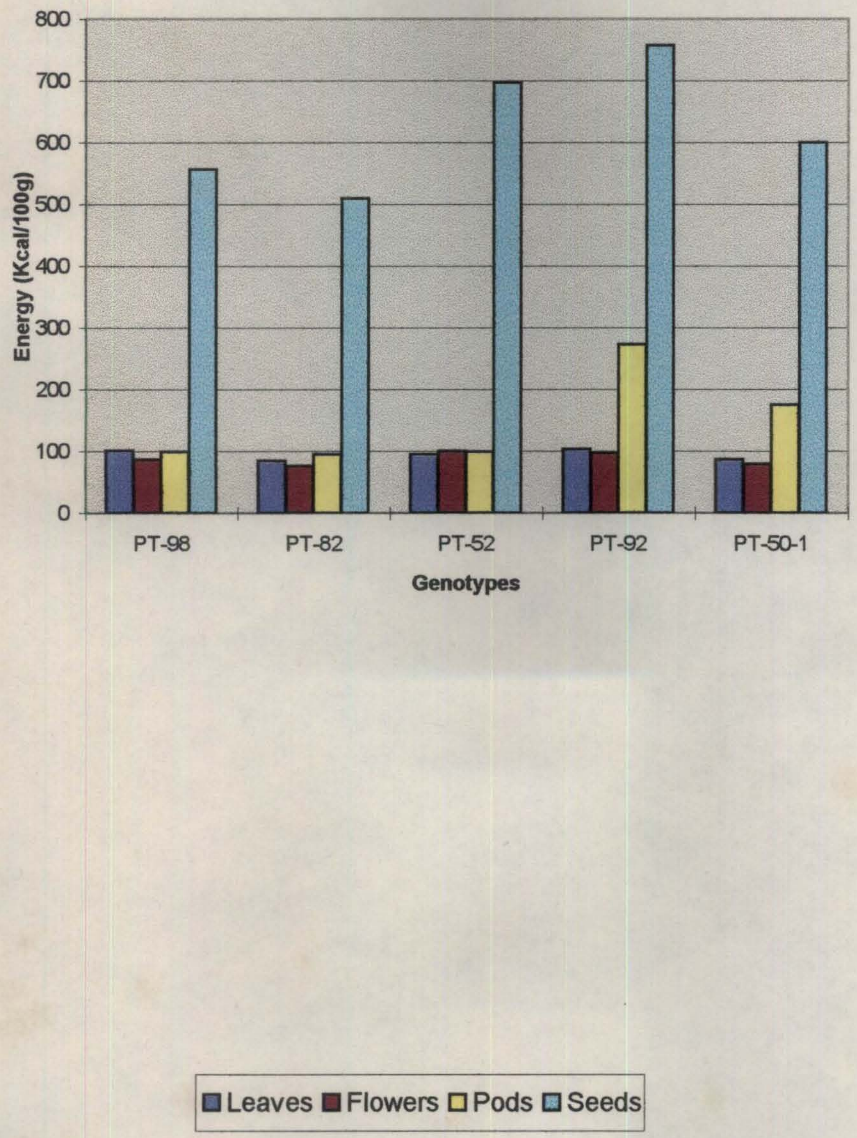


Table 13. Analysis of variance for energy in the edible parts of winged bean genotypes

Genotype	DF	Mean sum of squares			
		Leaves	Flowers	Pods	Seeds
Variety	4	212.400	337.833	17924.667	31082.1
Error	10	227.200	171.200	1004.933	1245.533
F value		0.935	1.973	17.837**	24.955**

** Significant at 1 per cent level

4.2.7 Calcium

The calcium content of the different edible parts of winged bean was analysed and the results are presented in Table 14 and the results of statistical analysis are given in Table 15.

As shown in Table 14, the leaves had a calcium content ranging from 209.6-299.9 mg per 100 g with a mean value of 245.46 mg per 100 g. The leaves of the genotype PT-82 had the highest calcium content while the leaves of PT-98 had the lowest calcium content. Statistical analysis showed that variations in the calcium content of the leaves between the different genotypes was significant.

The calcium content of the flowers ranged from 113-147.9 mg per 100 g. The mean calcium content of the flowers was found to be 138.04 mg per 100 g. Variations in the calcium content of the flowers between the different genotypes was found to be statistically significant. The flowers of PT-52 had the highest calcium content while the flowers of PT-82 had the lowest calcium content.

In immature pods, the calcium content ranged from 165.4-249.4 mg per 100 g with a mean value of 201 mg per 100 g. The pods of PT-50-1 had the highest calcium content while the pods of PT-52 had the lowest calcium content. The results of statistical analysis showed that the variations in the calcium content of the flowers between the different genotypes was significant.

The dry seeds of winged bean had a calcium content ranging from 76.3-86.3 mg per 100 g. The mean calcium content of the dry seeds was found to be 80.86 mg per 100 g. Statistical analysis indicated significant variations in calcium content of the seeds between the different genotypes. The calcium content was maximum in the seeds of the genotype PT-98 and the minimum calcium content was found in PT-82.

Among the different plant parts, the highest calcium was present in the leaves of all the four genotypes except PT-98 in which the pods had the maximum calcium content (212.7 mg per cent) (Fig.7). The seeds of all the five genotypes had the lowest calcium content with a least value of 76.3 mg per cent in PT-82.

Table 14. Calcium content of the edible parts of winged bean genotypes (mg/100 g) (dry weight basis)

Genotype	Plant part			
	Leaves	Flowers	Pods	Seeds
PT-98	209.6	142.3	212.7	86.3
PT-82	299.9	113.0	211.1	76.3
PT-52	228.7	147.9	165.4	80.6
PT-92	232.4	140.4	166.4	79.1
PT-50-1	256.7	146.6	249.4	82.0
Mean	245.46	138.04	201.0	80.86
CD	13.818	8.489	16.318	4.799

Fig. 7. Calcium contents of edible parts of winged bean genotypes (mg/100g)

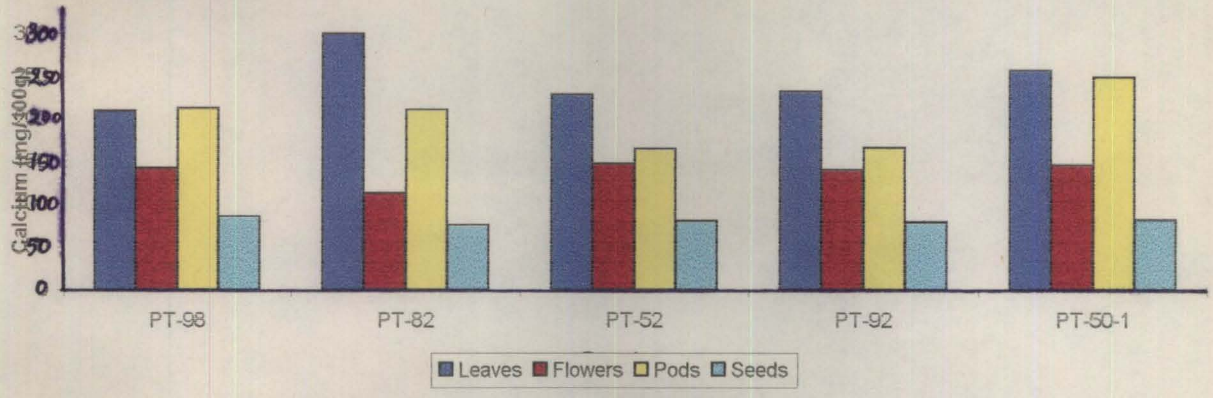


Table 15. Analysis of variance for calcium in the edible parts of winged bean genotypes

Genotype	DF	Mean sum of squares			
		Leaves	Flowers	Pods	Seeds
Variety	4	7524.886	1434.814	8830.386	95.714
Error	30	160.705	60.657	224.114	19.381
F value		48.824**	25.654**	39.401**	4.939**

** Significant at 1 per cent level

4.2.8 Iron

The iron content of the different edible parts of winged bean are presented in Table 16 and the results of the statistical analysis are given in Table 17.

The iron content in leaves varied from 1.4 to 3.06 mg per 100 g with PT-82 leaves having the maximum iron content and the leaves of PT-98 having the minimum iron (Table 16). The mean iron content was found to be 2.2 mg per 100 g with statistically significant varitions between the different genotypes (Table 17).

In flowers, the iron content varied from a maximum of 1.74 mg per 100 g in the genotype PT-50-1 to a minimum of 1.36 mg per 100 g in the genotype PT-98 with a mean value of 1.48 mg per 100 g. Statistical analysis revealed that the variations in the iron content of the flowers between the different genotypes was significant.

The iron content of the immature pods varied from 0.56-1.41 mg per 100 g with statistically significant variations between the different genotypes. The highest iron content was observed in PT-98 while the pods of PT-50-1 had the lowest iron content with a mean value of 0.96 mg per cent.

In the dry seeds of winged bean, the iron content ranged from 0.85-1.31 mg per 100 g with a mean value of 1.07 mg per 100 g. The variations in the iron content of the seeds between the different genotypes was found to be statistically significant.

As revealed in Fig.8, among the different plant parts studied, the leaves had the maximum iron content with the flowers also being good sources of iron. Among the different plant parts, the leaves of PT-82 had the maximum iron content. The lowest iron content was observed in the pods of PT-50-1.

Table 16. Iron content of the edible parts of winged bean genotypes (mg/100 g) (dry weight basis)

Genotype	Plant part			
	Leaves	Flowers	Pods	Seeds
PT-98	1.40	1.36	1.41	1.15
PT-82	3.06	1.49	1.35	0.85
PT-52	1.89	1.40	0.77	1.31
PT-92	2.32	1.39	0.69	0.92
PT-50-1	2.32	1.74	0.56	1.11
Mean	2.20	1.48	0.96	1.07
CD	0.109	0.129	0.109	0.097

Fig.8. Iron content of edible parts of winged bean genotypes

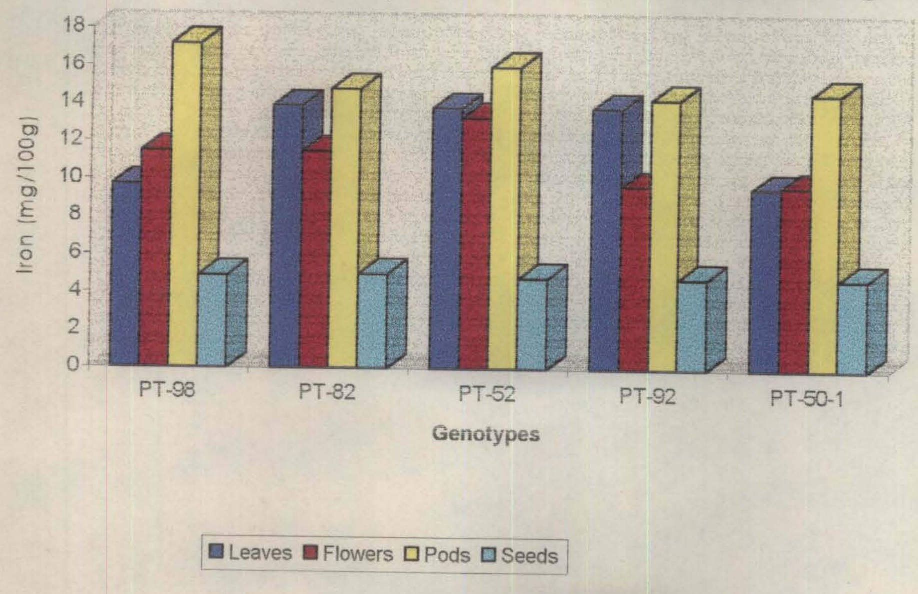


Table 17. Analysis of variance for iron in the edible parts of winged bean genotypes

Genotype	DF	Mean sum of squares			
		Leaves	Flowers	Pods	Seeds
Variety	4	2.628	0.168	1.092	0.244
Error	30	0.010	0.014	0.007	0.008
F value		255.803**	11.884**	149.039**	31.961**

** Significant at 1 per cent level

4.2.9 Vitamin C

The mean vitamin C content of the different edible parts (fresh weight basis) of the five winged bean genotypes are presented in Table 18 and the results of statistical analysis are given in Table 19.

As shown in Table 18 the vitamin C content of the leaves of winged bean varied from 9.6-13.9 mg per 100 g with a mean vitamin C content of 12.16mg per 100 g. There was significant variation in the vitamin C content of the leaves between the different genotypes with the maximum vitamin C content in PT-82 and the minimum vitamin C content in PT-50-1.

In flowers, the vitamin C content ranged from 9.7 to 13.3 mg per cent with the highest vitamin C content in PT-52 and the lowest in PT-92 and PT-50-1. The mean vitamin C content of the flowers was found to be 11.14 mg per 100 g and statistical analysis revealed that the variation in the vitamin C content between the different genotypes was statistically significant.

The vitamin C content of the immature pods was found to be between 14.3 to 17.2 mg per cent with a mean vitamin C content of 15.26 mg per 100 g. The highest vitamin C content was found in the pods of PT-98 and the minimum vitamin C content was seen in the genotype PT-92. The variations in the vitamin C content of the pods between the different genotypes was found to be statistically significant.

The dry seeds had a vitamin C content ranging from 4.8-5.0 mg per cent with a mean value of 4.86 mg per 100 g. The results were statistically analysed and it was revealed that the vitamin C content of the seeds of the different genotypes varied significantly.

Among the different plant parts the immature pods of all the five genotypes contained the maximum vitamin C while the minimum vitamin C was found in the dry seeds of all the genotypes. The highest vitamin C content was seen in the pods of PT-98 while the lowest vitamin C was present in the seeds of the genotypes PT-52, PT-92 and PT-50-1 (4.8 mg/100 g). A comparison of the vitamin C content of the different edible parts of winged bean genotypes is presented in Fig.9.

Table 18. Vitamin C content of the edible parts of winged bean genotypes (mg/100 g) (fresh weight basis)

Genotype	Plant part			
	Leaves	Flowers	Pods	Seeds
PT-98	9.7	11.5	17.2	4.9
PT-82	13.9	11.5	14.8	5.0
PT-52	13.8	13.3	16.0	4.8
PT-92	13.8	9.7	14.3	4.8
PT-50-1	9.6	9.7	14.6	4.8
Mean	12.16	11.14	15.26	4.86
CD	0.415	1.241	1.598	0.351

Fig.9. Vitamin C content of edible parts of winged bean genotypes (mg/100g)

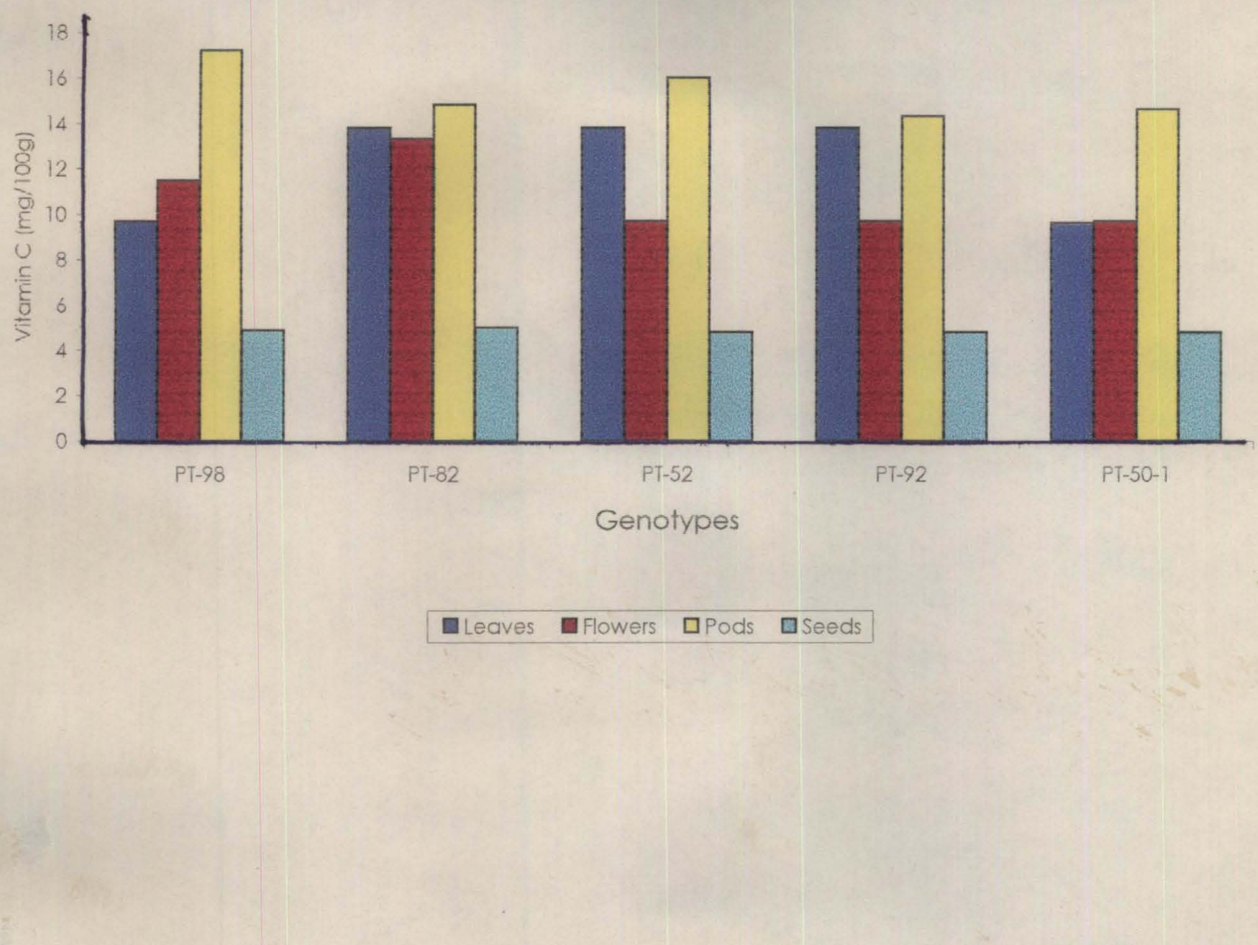


Table 19. Analysis of variance for Vitamin C in the edible parts of winged bean genotypes

Genotype	DF	Mean sum of squares			
		Leaves	Flowers	Pods	Seeds
Variety	4	36.262	15.884	0.034	9.911
Error	30	0.145	1.297	0.104	2.148
F value		250.309**	12.245**	0.322	4.615**

** Significant at 1 per cent level

4.2.10 Tannin content in the seeds

The tannin content in the winged bean seeds of the five genotypes was analysed before and after cooking and the results are presented in Table 20.

The tannin content in the raw winged bean seeds ranged from 0.65-0.92 g with a mean value of 0.82 g per 100 g. The highest tannin content was present in the genotype PT-50-1 and the lowest in the genotype PT-52. Statistical analysis revealed that the tannin content of the raw winged bean seeds varied significantly between the different genotypes.

The tannin content of the seeds was analysed after cooking the soaked seeds for 30 minutes in water. In the cooked winged bean genotypes the tannin content ranged from 0.46 to 0.70 g per cent with a mean tannin content of 0.62 g per cent. The genotype PT-52 had the lowest tannin content followed by PT-98, PT-50-1, PT-92 and PT-82.

From Table 19 it is clear that there is a decrease in the tannin content of the winged bean seeds after cooking. The percentage decrease in tannin content varied from 14.81 to 29.23 per cent with a maximum decrease in PT-52 and a minimum decrease in PT-92.

Statistical analysis indicated that the tannin content in the different winged bean genotypes varied significantly before and after cooking (Table 21). The tannin content of the seeds of winged bean genotypes before and after cooking is represented in Fig.10.

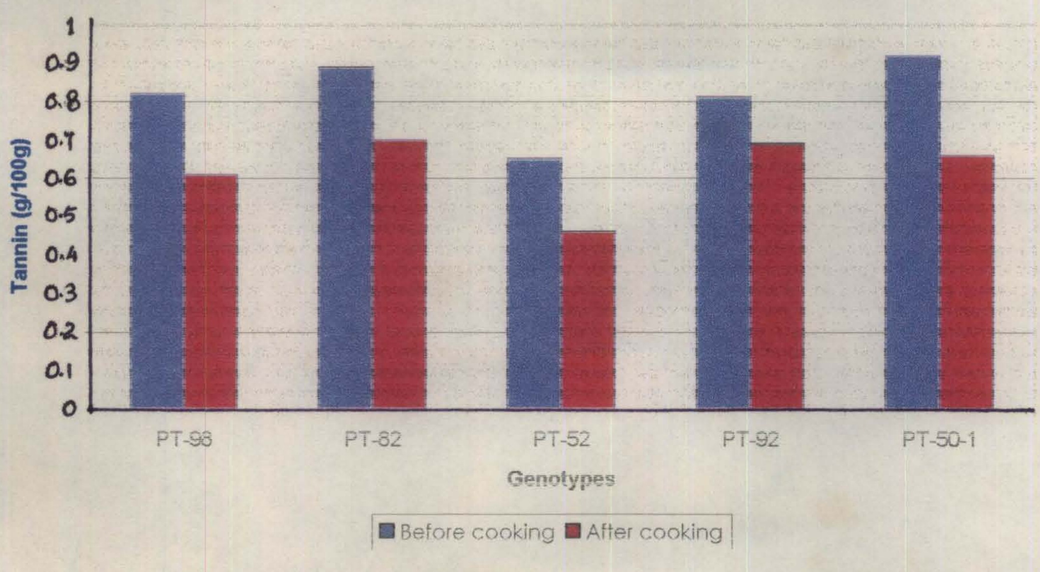
Table 20. Tannin content of the seeds of winged bean (g/100 g)

Genotype	Before cooking	After cooking	Percentage of decrease
PT-98	0.82	0.61	25.60
PT-82	0.89	0.70	21.35
PT-52	0.65	0.46	29.23
PT-92	0.81	0.69	14.81
PT-50-1	0.92	0.66	28.26
Mean	0.82	0.62	23.85
CD	0.060	0.034	

Table 21. Analysis of variance for the tannin in the ~~edible parts~~ seeds of winged bean genotypes

Source	DF	Mean sum of squares	
		Before cooking	After cooking
Variety	4	0.076	0.070
Error	30	0.003	0.001
F value		30.153**	55.727**

Fig.10. Tannin content of seeds before and after cooking (g/100g)



4.3 Organoleptic qualities of winged bean genotypes

The acceptability studies of the leaves, flowers, pods and dry seeds of the five winged bean genotypes were conducted by score card method. A five-point hedonic scale was used to score each character and the mean scores obtained for different characteristics like colour, doneness, texture, flavour and taste of the four edible parts of the winged bean genotypes are presented in Tables 22, 23, 24 and 25.

From Table 22 it is evident that the leaves of all the genotypes had the same mean score with respect to colour. When the character doneness was analysed, the genotype PT-98 was found to have the maximum score while the minimum score was obtained for the genotype PT-92.

The leaves of all the five genotypes were found to have only a fair score with respect to texture, with the genotypes PT-82 and PT-52 having a score of 3 and the genotype PT-50-1 having a score of 2.8. The flavour of all the genotypes was good with a maximum score of 3.8 for PT-92 and PT-50-1 and the minimum score (3.4) for the genotype PT-52. With regard to the character taste, the genotype PT-52 had the maximum score, while the minimum score was seen in PT-92.

When all the characters were analysed together to find out the overall acceptability of leaves, it was found that there was not much variations in the total scores between the different genotypes. Taking the total scores for the different quality attributes of the leaves of the five genotypes, it was found that two genotypes, namely PT-92 and PT-50-1 had the maximum total score (18.3) while the minimum total score was seen in the genotype PT-82 (18.1).

Statistical analysis by `Friedmans Two Way Analysis of Variance by Ranks' (Siegel, 1956) revealed that there was no significant variation in the quality attributes of the leaves between the different genotypes.

Table 22. Mean scores of the acceptability tests in leaves

Character	Genotype				
	PT-98	PT-82	PT-52	PT-92	PT-50-1
Colour	3.8	3.8	3.8	3.8	3.8
Doneness	4.6	4.4	4.5	4.1	4.5
Texture	2.9	3.0	3.0	2.9	2.8
Flavour	3.5	3.5	3.4	3.8	3.8
Taste	3.4	3.4	3.5	3.3	3.4
Total	18.2	18.1	18.2	18.3	18.3

The flowers of all the five genotypes of winged bean were analysed for the different quality attributes and the results are given in Table 23. It was found that the genotype PT-82 had the highest score (3.9) for colour while the lowest score (3.7) was seen in the genotype PT-52.

The scores for doneness did not vary much between the different genotypes with two genotypes namely PT-92 and PT-50-1 having the same scores of 4.5 and three genotypes namely PT-98, PT-82 and PT-52 having a score of 4.3.

In texture, the genotype PT-50-1 was found to have the highest score (3.6) while the genotype PT-52 had the lowest score (3.3).

The scores for flavour were found to be almost the same for all the genotypes with four genotypes namely PT-98, PT-82, PT-52 and PT-50-1 having a maximum score of 3.6 and the genotype PT-92 having a score of 3.5. The genotype PT-98 had the maximum score for taste while the minimum score was for the genotype PT-50-1 (3.5).

Taking the total scores for the different quality attributes of flowers of the five genotypes selected for the study it was found that three genotypes namely PT-82, PT-92 and PT-50-1 had the maximum total score (19.0) while the genotype PT-52 had the minimum total score (18.6).

Statistical analysis revealed that there was no significant variation in the quality attributes of the flowers between the different genotypes.

Table 23. Mean scores of the acceptability tests in flowers

Character	Genotype				
	PT-98	PT-82	PT-52	PT-92	PT-50-1
Colour	3.8	3.9	3.7	3.8	3.8
Doneness	4.3	4.3	4.3	4.5	4.5
Texture	3.4	3.5	3.3	3.5	3.6
Flavour	3.6	3.6	3.6	3.5	3.6
Taste	3.8	3.7	3.7	3.7	3.5
Total	18.9	19.0	18.6	19.0	19.0

In immature pods, the maximum score (4.0) for the attribute colour was seen in the genotype PT-92 while the minimum score (3.7) was seen in the genotype PT-50-1 (Table 24).

The scores for doneness of all the five genotypes were high (4.8) with two genotypes namely PT-98 and PT-82 having the maximum score and the genotype PT-50-1 having the minimum score (4.3).

All the five genotypes of immature pods were found to have low scores for texture. The maximum score (3.3) for texture was seen in the genotype PT-98 and the lowest score (3.0) was seen in three genotypes namely PT-52, PT-92 and PT-50-1.

The highest score (3.8) for flavour was seen in two genotypes namely PT-98 and PT-82 while the lowest score (3.3) was seen in the genotype PT-50-1.

With respect to the attribute taste the maximum score (4.0) was seen in three genotypes namely PT-98, PT-82 and PT-92 while the lowest score (3.3) was seen in the genotype PT-50-1.

The total score for the different quality attributes of the immature pods of the five genotypes was statistically analysed by Friedman's test and it was found that there was no significant variations between the different genotypes. However, taking the total scores for all the attributes, it was found that the genotype PT-98 had the highest score (19.7) while the lowest score (17.6) was for the genotype PT-50-1.

Table 24. Mean scores of the acceptability tests in pods

Character	Genotype				
	PT-98	PT-82	PT-52	PT-92	PT-50-1
Colour	3.8	3.9	3.9	4.0	3.7
Doneness	4.8	4.8	4.7	4.6	4.3
Texture	3.3	3.1	3.0	3.0	3.0
Flavour	3.8	3.8	3.5	3.7	3.3
Taste	4.0	4.0	3.8	4.0	3.3
Total	19.7	19.6	18.9	19.3	17.6

The different quality attributes like colour, doneness, texture, flavour and taste were analysed in the seeds of all the five genotypes of winged bean and the results are presented in Table 25..

The results revealed that the maximum score (3.4) for colour was observed in the genotype PT-50-1 while the minimum score (3.0) was observed in the genotype PT-98.

With regard to doneness, the maximum score (4.7) was observed in two genotypes, namely PT-92 and PT-50-1 while the minimum score (3.6) was observed in PT-98.

The genotype PT-92 had the maximum score (4.2) for texture while the minimum score (3.3) was observed in PT-98 and PT-82.

The highest score of 3.5 for flavour was observed in the genotype PT-98. while the lowest score of 3.1 was observed in the genotype namely PT-52.

The character taste was best in the genotype PT-92 which had the highest score (4.3) while the seeds of the genotypes PT-82 and PT-52 had the lowest score (3.8) with regard to taste.

The total score obtained for the different characters by the seeds of the five genotypes of winged bean showed that the genotype PT-92 had the highest total score (19.8) while the lowest score (17.4) was observed in the genotype PT-98. Statistical analysis revealed that there was no significant variation in the quality attributes of the seeds between the different genotypes.

Table 25. Mean scores of the acceptability tests in seeds

Character	Genotype				
	PT-98	PT-82	PT-52	PT-92	PT-50-1
Colour	3.0	3.3	3.3	3.3	3.4
Doneness	3.6	4.0	4.1	4.7	4.7
Texture	3.3	3.3	3.8	4.2	4.1
Flavour	3.5	3.4	3.1	3.3	3.3
Taste	4.0	3.8	3.8	4.3	4.2
Total	17.4	17.8	18.1	19.8	19.7

The total scores obtained by each plant part of all the five genotypes of winged bean are presented in Table 26.

From the table, it is clear that there is not much variation in the total scores obtained by the different plant parts between the different genotypes. Taking the grand total scores obtained by each genotype for all the plant parts together, it can be seen that the genotype PT-92 is having the maximum score (76.4) and the genotype PT-98 is having the minimum score (74.2). With regard to acceptability PT-92 can be said to be the superior.

Table 26. Total scores obtained in the acceptability tests

Plant part	Genotype				
	PT-98	PT-82	PT-52	PT-92	PT-50-1
Leaves	18.2	18.1	18.2	18.3	18.3
Flowers	18.9	19.0	18.6	19.0	19.0
Pods	19.7	19.6	18.9	19.3	17.6
Seeds	17.4	17.8	18.1	19.8	19.7
Grand total	74.2	74.5	73.8	76.4	74.6

Discussion

DISCUSSION

The study on "Nutritional composition and acceptability of winged bean genotypes" was an assessment of the nutritional composition and organoleptic qualities of the five genotypes of winged bean.

The different edible parts of the five winged bean genotypes i.e., flowers, leaves, immature pods and mature dry seeds were analysed for important constituents like moisture, protein, fat, starch, fibre, energy, calcium, iron and vitamin C. Among the antinutritional factors tannin content of the mature dry seeds of the selected winged bean genotypes was analysed before and after cooking. The acceptability of the edible portions of the selected winged bean genotypes was also carried out through organoleptic evaluation using score card. The nutritional composition and acceptability of the winged bean genotypes are discussed below.

The mean moisture content of the edible parts of the winged bean ranged from 7.96 (seeds) to 71.54 (immature pods). Highest and lowest moisture contents were found in the immature pods (72%) and mature dry seeds (6.1%) of the genotype PT-52. The moisture content of the leaves, immature pods and mature dry seeds was found to be lower than the values reported by NAS (1975a); Jaffe and Korte (1976); Norgan *et al.* (1979); Garcia and Palmer (1980); Ekpenyong (1985); Misra and Misra (1985); Kailasapathy *et al.* (1985). The variation in the moisture content of the edible parts of winged bean may be due to the difference in the genotypes selected for the study and also due to seasonal and locational variations.

The crude protein content of the leaves, flowers and fresh pods of the winged bean ranged from 2.7 per cent to 4 per cent. Among these three edible parts the leaves of the genotype PT-52 had the highest protein content of 4 per cent. The protein content in the immature pods of the winged bean genotypes (2.7 per cent to 3 per cent) was found to be in accordance with the values reported by NAS (1975a) and Hettiarachchy *et al.* (1979). The protein content of the winged bean flowers (2.92%) obtained in this study was lower than the values reported by NAS (1975a) (5.6%) and higher than the values reported by Hettiarachchy *et al.* (1979) (1.25 to 2.65%).

The protein content of the leaves ranged from 3.0 per cent to 4 per cent with a mean value of 3.24 per cent. This was found to be lower than the values reported by NAS (1975a) and Kantha *et al.* (1978) who reported a value of 5.7 to 15 per cent and 4.5 to 11.8 per cent respectively in the winged bean leaves.

However, the mean protein content of the mature dry seeds was almost ten times higher than the mean values obtained for leaves, flowers and fresh pods. The protein content of the five genotypes ranged from 27.6 per cent to 31.8 per cent which was found to be in accordance with the values reported by NAS (1975a); Watson (1977) and Misra and Misra (1985) and lower than the values reported by Rockland *et al.* (1979); Ekpenyong (1985); Kantha *et al.* (1986); Misra *et al.* (1987) and Prakash *et al.* (1987).

The fat content of all the edible parts of the winged bean except the mature seeds was found to be lower than one per cent while the mature seeds had an exceptionally high fat content. This was in accordance with the general trend observed in most of the common vegetables and pulses used by Keralites.

The fat content of the fresh pods selected for the present study ranged from 0.5 to 0.7 per cent with a mean value of 0.62 per cent. This was found to be higher than the values reported by NAS (1975a). The fat content of the mature dry seeds was within the range reported by NAS (1975a); Misra and Misra (1985) and Misra *et al.* (1987). However, Rockland *et al.* (1979); Kailasapathy *et al.* (1985) and Geeta (1991) reported higher values than the values obtained in the present study.

According to Banerjee (1985) the fat content of the winged bean leaves ranged from 5.04 to 6.85 per cent which was very much higher than the values obtained in this study (0.6 to 0.7%).

The findings of the present study also indicated a significant difference in the fat content of the fresh pods and mature dry seeds between the genotypes selected for the study. This disagrees with the findings reported by Geeta (1991) who indicated that the varietal difference in the fat content of winged bean seeds was in significant.

The mean starch content of the different edible parts of winged bean genotypes ranged from 25.32 to 49.16 per cent. The highest starch content was observed in the mature seeds of winged bean followed by flowers, leaves and fresh pods. According to Kadam *et al.* (1981) mature seeds of winged bean contained 25 to 45 per cent carbohydrates which included starch, sugars, crude fibre, acid detergent fibre and neutral detergent fibre. The starch content of the dry seeds in the different genotypes ranged from 47.1 per cent to 51.2 per cent which was higher than the values reported by Norgan *et al.* (1979); Kadam *et al.* (1981); Ekpenyong (1985); Misra and Misra (1985); Misra *et al.* (1987). This again may be due to the varietal difference , seasonal and locational variations of the crop.

The starch content of the immature pods was also found to be higher than the values reported by Norgan *et al.* (1979).

Reports indicated that the winged bean seeds are rich in carbohydrates while the carbohydrate content was lower in other edible parts like leaves, flowers and immature pods. The results of the present study also indicated a similar trend with respect to starch in the different edible parts of winged bean.

Dietary fibre is a major component of vegetables. The results of the present study indicated that the leaves and pods of winged bean had a mean fibre content of 17.72 per cent and 17.28 per cent respectively. The fibre content of the commonly used green leafy vegetables like amaranth, cabbage, chekkurmanis and drumstick leaves ranged from 1 to 2 per cent (Gopalan *et al.*, 1989) where as the dried colocasia leaves and dried fetid cassia leaves had a higher fibre content of 16 per cent and 10.4 per cent respectively. The fibre content of the winged bean leaves obtained in the present study was also very high because the values are represented on dry matter basis.

The fibre content of the fresh pods ranged from 16.2 to 18.2 per cent which was higher than the values reported by NAS (1975a) and Norgan *et al.* (1979). This may be due to the variations in the time of harvest and difference in the genotypes.

The mean fibre content of the mature dry seeds was 10.58 per cent which agrees with the values reported by NAS (1975a) but disagrees with the values reported by Rockland *et al.* (1979) and Misra *et al.* (1987) who reported lower values of 7.5 per cent and 6.12 to 8.73 per cent in the winged bean seeds. However, Garcia and Palmer (1980); Misra and Misra (1985) and Sharma (1986) reported high fibre content of 14 per cent, 12.70 per cent and 35.2 per cent respectively in the winged bean seeds. These differences may be due to the difference in the genotypes selected for the study.

The calorific values of the different edible parts indicated that they are rich in energy. However, the energy content of the leaves, flowers and fresh pods were lower than those of the mature dry seeds. The high protein, fat and starch contents of the mature seeds contributed to the higher energy values obtained for the seeds. The energy content of the mature dry seeds of winged bean was found to be higher than the values reported by Janoria *et al.* (1984) which may again be due to the varietal differences.

Among the four edible parts of winged bean analysed for calcium, leaves had the highest content ranging from 209.6 mg to 256.7 mg with a mean value of 245.56 mg per 100 g. This agrees with the results reported by NAS (1975a) and Okezie and Martin (1980).

The mean calcium content of the fresh pods (201 mg/100 g) obtained in this study was within the calcium values of 63 to 330 mg/100g reported by NAS (1975a) and higher than the values of 33 mg/100 g reported by Iguchi *et al.* (1987).

The calcium content of the mature dry seeds was lower than the calcium content of other edible parts and varied from 76.3 mg to 86.3 mg with a mean value of 80.86 mg per 100 g. This was almost equal to the value of 88 mg/100 g reported by Janoria *et al.* (1984) and lower than the values reported by NAS (1975a), (204 to 307 mg/100 g); Rockland *et al.* (1979) (300 mg) and Kailasapathy and Nagalingam

(1986) (212 to 250 mg/100 g). However, Iguchi *et al.* (1987) obtained a lower calcium content (33 mg/100 g) in the winged bean seeds.

The leaves of winged bean contained a high amount of iron when compared to the other edible parts like flowers, fresh pods and mature seeds. The mean iron content of the fresh pods was lower than the values reported by NAS (1975a) and higher than the values reported by Iguchi *et al.* (1987). However, two genotypes namely PT-98 (1.41 mg/100 g) and PT-82 (1.35 mg/100g) had an iron content similar to the value of 1.3 to 1.7 mg/100 g reported by NAS (1975a).

The iron content of the dry seeds was also much lower than the values reported by NAS (1975a). But Janoria *et al.* (1984) reported an iron content of 2.2 mg/100 g in seeds which was higher than the values obtained in the present study.

The different edible portions of winged beans were fair sources of vitamin C. Even the mature dry seeds contained some amount (4.86 mg/100 g) of vitamin C. The highest vitamin C content was observed in the fresh pods (15.26 mg/100 g) while leaves (12.16 mg/100 g) and flowers (11.14 mg/100 g) contained almost similar amounts. Though the vitamin C content of the fresh pods was high when compared to the other parts, this was lower than the vitamin C content of the fresh pods reported by NAS (1975a).

Consumption of raw mature seeds of winged beans by human beings appears to be undesirable due to the presence of several antinutritional factors like trypsin inhibitor, heamagglutinins, saponin, tannin and oxalic acid (Esake *et al.*, 1973; Claydon, 1978; Kotaru *et al.*, 1987; Misra *et al.* 1987 and Singh *et al.*, 1987). Jaffe and Korte (1976) observed 100 per cent mortality in rats fed with diets containing raw winged bean flour.

In the present study the tannin content of the mature dry seeds was estimated before and after cooking. The findings revealed that the tannin content of the winged bean genotypes varied from 0.65 g/100 g to 0.92 g/100 g. The genotype PT-52 had the lowest tannin content. These values were lower than the values reported by Delumen and Salamat (1980) (1.58%); Kadam and Salunkhe (1984) (1.3 to 1.4%); Kotaru *et al.* (1987) (1.35 to 6.75%) and Geeta (1991) (1.07 to 1.2%). However, Kantha *et al.* (1986) reported a tannin content of 0.02 to 0.07 per cent in the different varieties of winged bean seeds which was lower than the values obtained in the present study.

There are variations in the tannin content of winged bean varieties reported by various authors. This variation may be due to the difference in the genotypes selected for the study.

Several authors have reported the effect of heat treatments like cooking, roasting and autoclaving as well as other processing methods like fermentation and germination on the presence of antinutritional factors in winged bean (Delumen and Salamat, 1980; Tan *et al.*, 1984; Fernando and Bean, 1986 and Kadam *et al.*, 1987). Geeta (1991) observed that among the different methods cooking was the most effective method to reduce the tannin content of winged bean . The author reported a decrease of 50 per cent in the tannin content of the raw seeds after cooking. Kadam *et al.* (1987) and Hemalatha and Poddar (1995) also reported a reduction in the antinutritional factors after cooking.

In the present study a reduction of 24 per cent tannin was obtained in winged bean seeds after cooking the soaked seeds for thirty minutes. This finding disagrees with the findings reported by Geeta (1991). The increased presence of tannin observed after cooking in the present study may be due to the use of the soaked water itself for cooking the winged bean seeds.

The acceptability of the different edible parts of the five genotypes of winged bean was evaluated using score card.

The acceptability related to different genotypes of leaves, flowers, pods and seeds revealed that all the genotypes were equally acceptable. The major qualities studied were colour, doneness, texture, flavour and taste.

The acceptability tests of the leaves of the five genotypes showed that among the quality attributes, doneness had obtained the highest scores in all the genotypes. The quality attribute texture obtained the least score in all the five genotypes. There was not much difference in the scores for the different quality attributes between the different genotypes.

The results of the acceptability tests in flowers showed that the maximum score was obtained for the quality attribute doneness in all the five genotypes, while all the other quality attributes had obtained almost same scores. The differences in scores between the different genotypes for the different quality attributes was not significant.

In the pods also, the maximum score was obtained for the quality attribute doneness while the scores obtained for all the other quality attributes were almost same.

The seeds of all the five genotypes of winged bean except PT-98 obtained the maximum score for the quality attribute doneness. The high score for doneness in seeds may be due to the pressure cooking of the soaked seeds. The lower score for flavour and colour may also be accounted for by the pressure cooking.

Altogether, the acceptability of the different edible parts of winged beans i.e., the leaves, flowers, pods and seeds showed no significant variations between the different genotypes. The varietal differences did not affect the colour, doneness, texture, flavour or taste of the different edible parts.

Summary

SUMMARY

The study on "Nutritive value and acceptability of winged bean genotypes (*Psophocarpus tetragonolobus* L.)" was made to evaluate the chemical composition and acceptability of the leaves, flowers, immature pods and mature dry seeds of the five winged bean genotypes maintained in the Department of Olericulture, College of Horticulture, Kerala Agricultural University, Vellanikkara, Trichur. The five genotypes selected for the study were PT-98, PT-82, PT-52, PT-92 and PT-50-1.

The major constituents like moisture, protein, starch, fat, fibre, energy, calcium, iron and vitamin C were estimated in all the four edible parts of the selected winged bean genotypes. The antinutritional factor namely tannin was estimated in the mature dry seeds of the genotypes before and after cooking. The acceptability tests of all the four edible parts of the selected genotypes was carried out after cooking.

The results of the study indicated that among the four edible parts, the dry seeds contained a high percentage of protein than the other edible parts with a maximum protein content of 31.8 per cent in the genotype PT-82. The mean protein content of the seeds was found to be 29.82 per cent. The mean protein content of the leaves, flowers and fresh pods varied from 2.9 per cent to 3.24 per cent on dry weight basis with significant variations in the protein content of the leaves between the selected genotypes.

The dry seeds also contained higher percentage of starch and fat than the other three edible parts with statistically significant variations in the fat content of fresh pods and seeds and in the starch content of all the edible parts between the five genotypes selected for the study. The fibre content varied from 7.04 per cent in

the flowers to 17.72 per cent in the leaves with significant variations in all parts except the seeds between the genotypes.

Corresponding to the high content of protein, starch and fat in the dry seeds, the calorific value of the seeds was also found to be very high than the other plant parts. The variations between the genotypes was found to be significant in fresh pods and dry seeds.

One of the most important macro elements namely calcium was abundantly present in the leaves (245.46 mg/100 g) as well as immature pods (201 mg/100 g) with significant variations in all the edible parts between the genotypes. The micro element iron was present in higher quantities in the leaves (2.20 mg/100 g) and flowers (1.48 mg/100 g) with significant variations between the genotypes of all the plant parts.

The vitamin C content of the edible parts varied from 4.86 mg/100 g in the dry seeds to 15.26 mg/100 g in the immature pods. The vitamin C content of all the plant parts except the immature pods varied significantly between the selected genotypes.

Like the other commonly consumed pulses, winged bean seeds also contained the antinutritional factor tannin in varying amounts. The tannin content of the raw seeds varied from 0.65 to 0.92 g/100 g in the five genotypes with significant variations between the five genotypes. The tannin content of the seeds after cooking decreased to the extent of 14.81 per cent to 29.23 per cent in the selected genotypes with a maximum decrease in the genotype PT-52.

The acceptability of the edible parts of the five genotypes was evaluated using score card. The important characters like colour, doneness, texture, flavour and taste were evaluated by a panel of judges. The overall acceptability of the different plant parts indicated that there is no significant variations in the quality attributes among the five genotypes selected for the study.

The organoleptic evaluation of all the plant parts indicated that the genotype PT-92 is comparatively better than the other four genotypes with respect to overall acceptability.

Suggestions for future line of work

1. The nutritional composition of the other winged bean genotypes maintained in the Kerala Agricultural University may be evaluated.
2. The antinutritional factors other than tannin present in the winged bean seeds may be analysed.
3. The effect of different cooking and processing methods on the antinutritional factors present in the winged bean seeds may also be analysed.

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*Original not seen

Appendices

APPENDIX-I

ACCEPTABILITY EVALUATION OF WINGED BEAN

No.	Character	Description	Score	1	2	3	4	5
I	COLOUR	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
II	DONENESS	Adequately cooked	5					
		Soft	4					
		Mushy	3					
		Overcooked	2					
		Raw and slimy	1					
III	TEXTURE	Highly tender	5					
		Slightly tender	4					
		Neither tender nor fibrous	3					
		Slightly fibrous	2					
		Fibrous	1					
IV	FLAVOUR	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
V	TASTE	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					

NUTRITIVE VALUE AND ACCEPTABILITY OF WINGED BEAN GENOTYPES

(*Psophocarpus tetragonolobus* L.)

By

ANJU M. NEELIYARA

ABSTRACT OF A THESIS

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ABSTRACT

Winged bean (*Psophocarpus tetragonolobus* L.), though relatively unknown is a multipurpose legume which appears to meet many dietary needs of our country and will be of immense help in reducing protein calorie malnutrition. The present study was undertaken to estimate the nutritional composition and acceptability of the edible parts like leaves, flowers, immature pods and dry seeds of the five selected winged beans genotypes.

The different edible portions of winged bean were analysed for moisture, protein, starch, fat, fibre, energy, calcium, iron and vitamin C. The protein, starch, fat and energy contents of the seeds were found to be high when compared to the other edible parts. The seeds of winged bean can be said to be a rich source of protein, fat and energy. The leaves and flowers were found to be rich in minerals like calcium and iron while all the different edible parts were fair sources of vitamin C. The nutrient content of most of the edible parts varied significantly among the different genotypes selected for the study.

The antinutritional factor tannin, present in the seeds was analysed before and after cooking. On cooking, the tannin content of the seeds was found to decrease considerably.

The acceptability tests were carried out on the different edible parts. The different characters like colour, doneness, texture, flavour and taste were evaluated. Results showed that all the edible parts of winged bean were highly acceptable. There was no significant variation in the acceptability of the edible parts between the different genotypes.