ELSEVIER

Food Chemistry 64 (1999) 39–44

Food Chemistry

Chemical composition of beach pea (*Lathyrus maritimus* L.) plant parts

F. Shahidi [a,b,c,*], U.D. Chavan [a], A.K. Bal [c], D.B. McKenzie [d]

[a] *Department of Biochemistry, Memorial University of Newfoundland, St. John's, NF, Canada A1B 3X9*
[b] *PA Pure Additions Inc., Memorial University of Newfoundland, St. John's, NF, Canada A1B 3X9*
[c] *Department of Biology, Memorial University of Newfoundland, St. John's, NF, Canada A1B 3X9*
[d] *Atlantic Cool Climate Crop Research Centre, Agriculture and Agri-Food Canada, St. John's, NF, Canada A1E 5Y7*

Received 3 November 1997; received in revised form 26 March 1998; accepted 26 March 1998

Abstract

Samples of beach pea (*Lathyrus maritimus* L.) seeds and plant parts were analyzed for their chemical composition, total and free amino acids as well as minerals. The crude protein content of plant parts was from 10.7–28.0%, soluble proteins from 190–709 mg/100 g, lipid from 1.3–6.0%, ash 2.2–6.8%, crude fibre 10.7–35.5%, soluble sugars 0.1–12.2%, starch 0.8–26.5%, carbohydrate 55.8–81.5% and phenolic compounds from 0.5–3.0%. The amino acid profile of proteins of seeds and other plant parts of beach pea showed that they were deficient in sulphur-containing amino acids. Tryptophan was another limiting amino acid in plant parts, except in leaves (1.35 g/16 g N). The content of free amino acids was highest in branches plus stems (3148 mg/100 g) and lowest in pod shells (151 mg/100 g). Beach pea plant parts were a good source of minerals such as K, P, Ca, Mg, Na, Fe, Al and Zn.

1. Introduction

Beach pea *Lathyrus maritimus* (L.) Bigel, is a leguminous plant which grows along the sandy and gravel shorelines of Newfoundland, Canada, and is also found along the shorelines of Arctic and sub-Arctic regions from Greenland to Siberia and Japan (Fernald, 1950; Talbot and Talbot, 1994). The roots of the beach pea plant are nodulated by the nitrogen-fixing soil bacterium, *Rhizobium* under naturally growing conditions. Besides being a sandbinder (Allen and Allen, 1981), due to the horizontally growing underground stems and roots, it is sometimes used as a fodder for cattle (Bal and Barimah-Asare, 1992).

We have recently studied the gross chemical composition and proteins of beach pea. However, the nutritional quality of beach pea seeds and other parts of beach pea plant, as a source of food for humans and animal feed, remains unknown. Utilization of the whole plant as a green fodder, dry matter or ensiled may be practised (Leconte, 1974; Andrieu et al., 1982). The seeds have also been eaten by individuals where beach pea grows. Dried and ground whole-crops of green peas have been evaluated as feed for pigs (Lund et al., 1981; Hakansson and Malmlof, 1984). Much work on green pea (*Pisum sativum*) has been done regarding its suitability as a livestock feed (Moran et al., 1968; Davidson, 1977; Henry and Bourdon, 1977; Askbrant and Hakansson, 1984). In the present study, different parts of the beach pea plant have been examined for their nutritional quality and suitability as a feed or food item.

2. Materials and methods

2.1. Materials

Beach pea seeds (pods), leaves and branches plus stems were collected from Bellevue Beach in the province of Newfoundland and Labrador, in September and October of 1995 and 1996. The total fresh weight of plant parts was recorded before samples were dried, ground and stored for detailed chemical analyses.

2.2. Chemical analyses

Moisture, crude protein, lipid (hexane extract), ash, crude fibre and total carbohydrate contents (by

* Corresponding author.

0308-8146/98/$19.00
PII: S0308-8146(98)00097-1

difference) were determined by standard methods of AOAC (1990). Total soluble sugars were extracted in 80% (v/v) ethanol according to the procedure of Cerning and Guilhot (1973). Soluble sugars and reducing sugars in the ethanolic extracts were estimated by Nelson Somogyi's modified method (Nelson, 1944). The amount of non-reducing sugars was calculated from the difference between the contents of total soluble sugars and reducing sugars. The same ethanolic extract was used for the determination of soluble proteins according to Lowry *et al.*'s method (Lowry et al., 1951). Residue obtained after extraction of soluble sugars was used for starch determination. Starch was extracted in 52% (v/v) perchloric acid at room temperature. Quantitative determination of starch was carried out according to the colorimetric method of McCready et al. (1950). The total phenolics of beach pea seeds and other plant parts were isolated using the method of Shahidi and Naczk (1989) which was employed for evaluating rapeseed meals. One gram of sample was extracted at room temperature, three times, with 10 ml of a 70% (v/v) aqueous acetone for 30 min using a Polytron PT 3000 homogenizer (Brinkman Instruments, Rexdale, ON) for 1 min at 10 000 rpm. The slurry was centrifuged at 5000×**g** for 10 min; the supernatants were collected, combined and evaporated to dryness at 30°C under vacuum. The extracted total phenolics were then dissolved in 25 ml of methanol, centrifuged again and the content of total phenolics in methanol was determined colorimetrically according to the method of Swain and Hillis (1959). To 0.5 ml of a methanolic solution of phenolics, 0.5 ml Folin–Denis reagent, 1 ml saturated solution of sodium carbonate and 8 ml water were added and mixed well. Absorbance was read at 725 nm after 30 min standing at room temperature; trans-sinapic acid was used as a standard in these experiments. The percent phenolics in samples, expressed as trans-sinapic acid equivalents, on a dry weight basis, was then calculated.

2.3. Amino acids

Total amino acids were determined as described by Shahidi et al. (1992). Samples were freeze-dried and then hydrolysed for 24 h at 110°C using 6 M HCl (Blackburn, 1978). The HCl was removed under vacuum, and dried samples were reconstituted using a lithium citrate buffer at pH 2.2. The hydrolysed amino acids were then determined using a Beckman 121 MB amino acid analyzer (Beckman Instruments, Inc., Palo Alto, CA). Tryptophan was determined separately by hydrolysis of the sample under vacuum in 3 M mercaptoethanesulphonic acid at 110°C, as described by Penke et al. (1974). Cysteine and methionine were determined by performic acid oxidation of sample prior to hydrolysis in 6 M HCl, and were measured as cysteic acid and methionine sulphone, respectively (Blackburn, 1978).

For determination of free amino acids, 2 g of sample were homogenized using a Polytron PT 3000 homogenizer (Brinkman Instruments) in a 50 ml centrifuge tube with 20 ml of ice-cold 6% (v/v) perchloric acid for 2 min in an ice bath. The homogenized samples were then incubated in ice for 30 min before centrifugation (IEC Centra MP4 centrifuge, International Equipment Co., Needham Heights, MA) at 2000×***g*** for 15 min. The residue was then re-extracted with 20 ml ice-cold perchloric acid and centrifuged, as described above. The supernatants from the first and second extraction were combined and filtered through a Whatman No. 4 filter paper. The pH of the filtrate was adjusted (Accumet pH meter, model 810, Fisher Scientific Co., Fair Lawn, NJ) to 7.0 using a 33% (w/v) KOH solution and then centrifuged at 2000×***g*** for 10 min to remove precipitates of potassium perchlorate. The supernatant was acidified to pH 2.2 with a 10 M HCl and then diluted to 50 ml with distilled water. Two millilitres of the extract were transferred into a clean tube and 1.0 ml of lithium citrate buffer (pH 2.2; Beckman Instruments, Inc., Palo Alto, CA) was added to it. Samples were then analyzed on a Beckman 121 MB amino acid analyzer using Benson D-X 8.25 resin and a single column employing the three-buffer lithium method as per Beckman 121 MB-TB017 application notes. Results were calculated and reported as mg free amino acids/100 g sample.

2.4. Determination of mineral constituents

Dried and ground samples (1 to 2 g) were subjected to dry ashing in well cleaned porcelain crucibles at 550°C in a muffle furnace (Blue M Electric Company, Blue Island, IL). The resultant ash was dissolved in 5 ml of $HNO_3/HCl/H_2O$ (1:2:3, v/v/v) and heated gently on a hot plate until brown fumes disappeared. To the remaining material in each crucible, 5 ml of deionized water were added and heated until a colourless solution was obtained. The mineral solution in each crucible was transferred into a 100 ml volumetric flask following filtration through a Whatman No. 42 filter paper and the volume was made to the mark with deionized water. This solution was used for elemental analysis by atomic absorption spectrophotometry. The concentration of elements (Ca, Na, K, Mg, Mn, Zn, Fe, Cu, Li, Al, and Si) in each solution, prepared as described above, was determined using a Perkin Elmer 8650 atomic absorption spectrophotometer (Perkin–Elmer Co., Montreal, PQ). Calibration curves of absorbance values versus concentration of each element at appropriate concentrations (to obey Beer's–Lambert Law) were constructed using their respective standards of 1000 μg litre^{-1} (Fisher Scientific, Unionville, ON). A 10 cm-long cell was used and concentration of each element in the sample was calculated as mg/100 g of dry matter. Phosphorus content of the digest was determined color-

imetrically according to the method described by Nahapetian and Bassiri (1975). To 0.5 ml of the diluted digest, 4 ml of demineralized water, 3 ml of 0.75 M H_2SO_4, 0.4 ml of 10% (w/v) $(NH_4)_6Mo_7O_{24}.4H_2O$ and 0.4 ml of 2% (w/v) ascorbic acid were added and mixed. The solution was allowed to stand for 20 min and absorbance readings were recorded at 660 nm. The content of phosphorus in the extracts was determined using a standard curve obtained for KH_2PO_4 and expressed as mg phosphorus per 100 g of sample.

2.5. Statistical analysis

All determinations were replicated three times or more and mean values and standard deviations reported. Analyses of variance (ANOVA) were performed and differences in mean values were determined using Tukey's studentized test at $p < 0.05$ and employing ANOVA and Tukey procedures of statistical analytical systems (SAS, 1990).

3. Results and discussion

Chemical compositions of mature seeds, leaves, branches plus stems and mature pod shells are shown in Table 1. Seed constituents were dominated by crude protein (28.0%) and starch (26.5%) while generally lower amounts of them were present in the leaves (23.5 and 0.8%), branches plus stems (14.6 and 1.4%) and mature pod shells (10.7 and 2.2%). Singh and Jambunathan (1980) and Earle and Jones (1982) reported that there was a wide variation in seed protein content of all cultivated species of legumes and their protein content ranged from 14.9 to 45.0%. The mature pod shells contained higher amounts of carbohydrate (81.5%) and crude fibre (35.5%) than other plant parts. The total content of phenolics was 3.0% in leaves, 1.4% in seeds, 0.6% in pod shells and 0.5% in branches plus stems. In addition, green plant parts served as a good source of minerals and soluble sugars (Table 1). The ash content of seeds (3.1%) was similar to those reported for other legumes (Platt, 1980; Apata and Ologhobo, 1994).

Consideration of the overall chemical composition of leaves, branches plus stems and mature pod shells reveals that beach pea is a good source of nutrients for animal feed, as a fodder, or ensiled forage. These results are similar to those for green pea plant parts (Trevino et al., 1987). The protein, ash, crude fibre and phenolics contents of beach pea were slightly higher than those reported for other legumes (Moran et al., 1968; Wills et al., 1984, 1987; Kumar et al., 1991).

The amino acid compositions of seeds, leaves, branches plus stems and pod shells are given in Table 2. The contents of lysine (7.4 g/16 g N), arginine (8.0 g/16 g N) and glutamic acid (16.6 g/16 g N) in dried beach pea seeds were higher than other parts of the plant. The contents of these amino acids are fairly similar to those of faba bean (Hsu et al., 1980; Khalil and Mansour, 1995), field pea (Acikgoz et al., 1985), mungbean (Abdus Sattar et al., 1989), pigeon pea (Singh et al., 1990), flaxseed (Wanasundara and Shahidi, 1994), and Nigerian legume seeds, namely bambara groundnut, kidney bean, lima bean, pigeon pea and jack bean (Apata and Ologhobo, 1994). The amounts of methionine and cysteine in leaves and mature pod shells were higher than reference values given by FAO/WHO (1973). Tryptophan content was higher in leaves (1.4 g/16 g N) than the FAO/WHO/UNU (1985) reference value, but lower in all other parts of the plant. Total essential amino acids were higher in branches plus stems (45.8 g/16 g N) and lower in mature pod shells (39.8 g/16 g N). The non-essential amino acids were abundant in seeds (54.9 g/16g N), but less prevalant in mature pod

Table 1
Chemical composition of different plant parts of beach pea[a]

Constituent (%)	Seeds[b]	Leaves	Branches and stems	Mature pod shells
Moisture (wet weight basis)	11.8 ± 0.27^{c}	77.1 ± 1.74^{a}	76.6 ± 1.56^{a}	22.0 ± 0.84^{b}
Protein	28.0 ± 1.37^{a}	23.5 ± 0.07^{b}	14.6 ± 0.15^{c}	10.7 ± 0.18^{d}
Soluble proteins	290 ± 3.30^{c}	373 ± 1.58^{b}	709 ± 3.02^{a}	190 ± 1.59^{d}
Lipid (hexane extractable)	1.3 ± 0.14^{c}	6.0 ± 0.01^{a}	2.3 ± 0.21^{b}	1.4 ± 0.03^{c}
Ash	3.1 ± 0.03^{c}	6.8 ± 0.06^{a}	5.1 ± 0.10^{b}	2.2 ± 0.09^{d}
Crude fibre	10.7 ± 0.16^{c}	27.3 ± 0.67^{b}	34.5 ± 0.15^{a}	35.5 ± 0.48^{a}
Carbohydrates[c]	55.8 ± 0.78^{d}	57.3 ± 0.11^{c}	70.2 ± 0.18^{b}	81.5 ± 0.17^{a}
Soluble sugars	2.8 ± 0.04^{c}	4.0 ± 0.49^{b}	12.2 ± 0.14^{a}	0.1 ± 0.01^{d}
Reducing sugars (mg/100g)	165 ± 0.02^{c}	1071 ± 1.12^{b}	5471 ± 2.80^{a}	39.1 ± 0.01^{d}
Non-reducing sugars	2.6 ± 0.04^{b}	3.0 ± 0.49^{b}	6.8 ± 0.35^{a}	0.0 ± 0.01^{c}
Starch	26.5 ± 0.46^{a}	0.8 ± 0.07^{c}	1.4 ± 0.04^{c}	2.2 ± 0.06^{b}
Phenolics	1.4 ± 0.01^{b}	3.0 ± 0.02^{a}	0.5 ± 0.07^{c}	0.6 ± 0.01^{c}

[a] Results are mean values of triplicate determinations, ± standard deviation and are expressed on a dry weight basis, unless otherwise specified. Means followed by different superscripts in each row are significantly ($p < 0.05$) different from one another.

[b] Values are for mature seeds.

[c] By difference.

shells (43.6 g/16 g N). The high content of leucine, lysine, arginine and glutamic acid in beach pea seeds supports the results of other investigators for other legume seeds (Evans and Bendemer, 1967; Meredith and Thomas, 1982; Khalil and Mansour, 1995; Mohan and Janardhanan, 1995).

Free amino acids of different parts of beach pea plant are presented in Table 3. Seeds contained mainly arginine (128.6 mg/100 g), but its amount was less in branches plus stems (76.0 mg/100 g), leaves (23.9 mg/100 g) and mature pod shells (12.4 mg/100 g). Leaves and branches plus stems had higher amounts of asparagine,

Table 2
Total amino acid composition of different plant parts of beach pea[a]

Amino acid	Seeds[b]	Leaves	Branches and stems	Mature pod shells
Alanine	4.3 ± 0.13^{c}	5.5 ± 0.09^{a}	5.5 ± 0.20^{a}	4.4 ± 0.05^{bc}
Arginine	8.0 ± 0.19^{a}	4.7 ± 0.18^{cd}	5.1 ± 0.22^{bc}	4.5 ± 0.10^{d}
Aspartic acid + Asparagine	13.0 ± 0.13^{b}	15.1 ± 0.74^{a}	3.8 ± 0.16^{d}	10.3 ± 0.21^{c}
Cysteine	1.7 ± 0.04^{b}	1.5 ± 0.02^{d}	1.5 ± 0.06^{cd}	1.8 ± 0.02^{a}
Glutamic acid + Glutamine	16.6 ± 0.31^{a}	9.7 ± 0.17^{bc}	9.5 ± 0.38^{cd}	8.8 ± 0.09^{d}
Glycine	4.1 ± 0.12^{b}	4.7 ± 0.09^{a}	5.0 ± 0.18^{a}	4.8 ± 0.03^{a}
Histidine	2.6 ± 0.01^{bcd}	2.4 ± 0.02^{d}	3.6 ± 0.12^{a}	2.5 ± 0.01^{cd}
Isoleucine	4.0 ± 0.01^{bc}	4.2 ± 0.14^{ab}	4.4 ± 0.26^{a}	3.7 ± 0.02^{c}
Leucine	7.5 ± 0.16^{a}	7.6 ± 0.16^{a}	6.6 ± 0.30^{bc}	6.2 ± 0.01^{c}
Lysine	7.4 ± 0.15^{a}	6.4 ± 0.10^{a}	7.0 ± 0.33^{a}	8.2 ± 1.72^{a}
Methionine	1.1 ± 0.03^{cd}	1.6 ± 0.03^{a}	1.3 ± 0.08^{b}	1.1 ± 0.02^{d}
Phenylalanine	4.6 ± 0.10^{bc}	5.3 ± 0.13^{a}	4.6 ± 0.29^{c}	3.7 ± 0.01^{d}
Proline	4.0 ± 0.14^{d}	7.0 ± 0.15^{b}	8.5 ± 0.09^{a}	5.0 ± 0.20^{c}
Serine	5.0 ± 0.14^{d}	5.4 ± 0.06^{c}	8.6 ± 0.31^{a}	5.8 ± 0.02^{bc}
Threonine	4.2 ± 0.10^{d}	4.9 ± 0.06^{b}	5.7 ± 0.08^{a}	4.2 ± 0.02^{cd}
Tryptophan	0.3 ± 0.02^{d}	1.4 ± 0.02^{a}	0.6 ± 0.02^{b}	0.4 ± 0.01^{c}
Tyrosine	3.3 ± 0.05^{bc}	3.9 ± 0.35^{a}	4.4 ± 0.30^{a}	3.2 ± 0.05^{c}
Valine	4.7 ± 0.01^{d}	5.5 ± 0.21^{b}	6.2 ± 0.38^{a}	4.9 ± 0.01^{cd}

[a] Results are mean of triplicate determinations, on a dry weight basis, ± standard deviation and expressed as g/16 g N. Means followed by different superscripts in each row are significantly ($p < 0.05$) different from one another.
[b] Values are for mature seeds.

Table 3
Free amino acid composition of different plant parts of beach pea[a]

Free amino acid	Seeds[b]	Leaves	Branches and stems	Mature pod shells
Alanine	20.7 ± 0.54^{c}	110.3 ± 1.20^{a}	91.9 ± 2.95^{b}	4.7 ± 0.12^{d}
Arginine	129 ± 1.24^{a}	23.9 ± 0.15^{c}	76.0 ± 1.63^{b}	12.4 ± 0.28^{d}
Asparagine	109 ± 7.23^{c}	991 ± 2.37^{b}	1765 ± 7.70^{a}	24.6 ± 0.33^{d}
Aspartic acid	32.7 ± 2.20^{bc}	32.3 ± 2.22^{c}	43.1 ± 1.75^{a}	4.2 ± 0.17^{d}
Cysteine	16.5 ± 1.95^{b}	31.4 ± 1.41^{a}	33.6 ± 1.82^{a}	2.9 ± 0.57^{c}
Glutamic acid	11.8 ± 4.67^{d}	45.2 ± 1.24^{a}	28.6 ± 2.00^{c}	31.9 ± 0.32^{bc}
Glutamine	1.8 ± 0.76^{d}	98.0 ± 2.98^{a}	67.0 ± 2.15^{b}	21.6 ± 0.23^{c}
Glycine	12.9 ± 0.59^{a}	7.6 ± 0.04^{b}	6.0 ± 0.53^{c}	1.5 ± 0.23^{d}
Histidine	10.6 ± 0.75^{c}	88.4 ± 2.90^{a}	64.4 ± 2.15^{b}	2.8 ± 0.03^{d}
Hydroxyproline	1.8 ± 0.34^{a}	ND	0.7 ± 0.05^{bc}	0.7 ± 0.05^{c}
Isoleucine	7.5 ± 0.41^{b}	44.3 ± 0.51^{a}	45.3 ± 1.01^{a}	0.9 ± 0.09^{c}
Leucine	10.2 ± 1.05^{c}	45.3 ± 0.29^{a}	32.3 ± 0.33^{b}	1.1 ± 0.16^{d}
Lysine	20.2 ± 0.27^{b}	26.9 ± 0.42^{a}	18.4 ± 0.07^{c}	4.3 ± 0.16^{d}
Methionine	27.9 ± 1.82^{a}	12.4 ± 0.23^{b}	8.5 ± 0.19^{c}	2.8 ± 0.51^{d}
Phenylalanine	4.1 ± 0.21^{c}	139 ± 1.76^{a}	47.4 ± 1.09^{b}	0.6 ± 0.00^{d}
Proline	42.2 ± 1.33^{c}	683 ± 1.86^{a}	344 ± 1.53^{b}	23.0 ± 0.27^{d}
Serine	16.0 ± 0.10^{c}	86.5 ± 2.82^{b}	279 ± 7.91^{a}	4.5 ± 0.25^{d}
Tyrosine	5.1 ± 0.10^{c}	41.6 ± 0.22^{a}	11.1 ± 0.10^{b}	0.4 ± 0.03^{d}
Threonine	10.5 ± 0.55^{c}	111.1 ± 2.45^{a}	101.1 ± 4.34^{b}	3.1 ± 0.04^{d}
Tryptophan	7.1 ± 0.41^{b}	69.9 ± 1.36^{a}	3.9 ± 0.03^{c}	0.7 ± 0.48^{d}
Valine	6.4 ± 0.04^{c}	120.6 ± 1.19^{a}	80.2 ± 1.24^{b}	2.0 ± 0.53^{d}
Total	503.9	2809.3	3147.9	150.7

[a] Results are mean of triplicate determinations, on a dry weight basis, ± standard deviation and expressed as mg/100 g. Means followed by different superscripts in each row are significantly ($p < 0.05$) different from one another. ND, not detected.
[b] Values are for mature seeds.

Table 4
Mineral composition of beach pea plant parts on a dry weight basis[a]

Minerals	Seeds[b]	Leaves	Branches and stems	Mature pod shells
Macroelements				
Calcium	139 ± 0.31^{d}	1630 ± 2.94^{a}	387 ± 1.34^{b}	263 ± 1.06^{c}
Magnesium	183 ± 1.42^{c}	393 ± 0.61^{a}	200 ± 1.47^{b}	157 ± 1.45^{d}
Phosphorus	434 ± 0.82^{a}	231 ± 1.28^{b}	184 ± 1.52^{c}	51 ± 0.52^{d}
Potassium	451 ± 2.02^{d}	504 ± 1.91^{c}	554 ± 1.85^{b}	627 ± 1.10^{a}
Sodium	112.7 ± 2.79^{c}	350.9 ± 0.93^{a}	354.7 ± 1.84^{a}	264.4 ± 1.07^{b}
Microelements				
Aluminum	3.1 ± 0.36^{d}	17.3 ± 0.46^{b}	26.0 ± 0.19^{a}	11.3 ± 0.60^{c}
Copper	0.9 ± 0.19^{a}	0.9 ± 0.19^{a}	0.7 ± 0.11^{a}	0.7 ± 0.11^{a}
Iron	8.8 ± 0.37^{d}	25.9 ± 0.66^{b}	12.8 ± 0.73^{c}	34.2 ± 0.41^{a}
Lithium	1.1 ± 0.07^{bc}	2.5 ± 0.54^{a}	3.1 ± 0.59^{a}	0.8 ± 0.50^{c}
Manganese	3.8 ± 0.51^{bc}	3.4 ± 0.60^{c}	1.7 ± 0.18^{d}	5.7 ± 0.95^{a}
Silicon	ND	41.1 ± 0.22^{b}	75.6 ± 0.28^{a}	23.0 ± 0.86^{c}
Zinc	3.1 ± 0.04^{a}	2.1 ± 0.12^{c}	2.5 ± 0.17^{b}	0.6 ± 0.07^{d}

[a] Results are mean of triplicate determinations, on a dry weight asis, ± standard deviation and expressed as mg/100 g. Means followed by different superscripts in each row are significantly ($p < 0.05$) different from one another. ND, not detected.
[b] Values are for mature seeds.

proline, valine, serine, alanine, glutamine and histidine than the seeds and mature pod shells.

The mineral contents of dry seeds and different plant parts of beach pea are shown in Table 4. Potassium (K) was the most abundant macroelement present, ranging from 627 mg/100 g in mature pod shells to 451 mg/100 g in seeds, followed by calcium (Ca) which was present from 1630 mg/100 g in leaves to 139 mg/100 g in seeds. The content of phosphorus (P) in seeds (434 mg/100 g) and magnesium (Mg) in leaves (393 mg/100 g) were highest as compared to other plant parts. Sodium (Na) content was highest in branches plus stems (355 mg/100 g) and lowest (113 mg/100 g) in seeds. Khalil and Mansour (1995) reported that faba beans contained 297 mg/100 g sodium. However, sodium content in beach pea seeds and other parts of plant was higher than that for other legumes (from 11.5 to 40.1 mg/100 g), as reported by Salunkhe et al. (1985). Among microelements, manganese was present at 5.7–34.2 and iron at 1.7–8.8 mg/100 g in mature pod shells, branches plus stems and seeds. The highest level of aluminium (Al) was present in branches plus stems (26.0 mg/100 g) and lowest in seeds (3.1 mg/100 g). Silicon (Si) was absent in seeds but was present in highest amount in branches plus stems (75.6 mg/100 g). Seeds contained 3.1 and 0.9 mg/100 g zinc (Zn) and copper (Cu), respectively. Thus, all parts of beach pea plant may serve as a valuable source of essential minerals for human and animal nutrition. Results of minerals for beach pea are comparable with those of tropical legumes such as the African locust bean, groundnut (Oyenuga, 1968), lathyrus and medicago (Varnaite, 1984), field pea (Acikgoz et al., 1985), cowpea (Jagadi et al., 1987), chickpea, green pea, pigeonpea, cowpea and *Lathyrus* beans (Salunkhe and Kadam, 1989), bambara groundnut, kidney bean, lima bean, jack bean and pigeon pea (Apata and Ologhobo, 1994), as well as other Mexican and North American beans (Meiners et al., 1976; Platt, 1980; D'mello et al., 1985; Zacharie and Ronald, 1993; Barrado et al., 1994). However, the lower sodium content of beach pea as compared to other leguminous seeds might be an added advantage due to the direct relationship of sodium intake with hypertension in humans (Dahl, 1972).

Acknowledgements

Financial assistance form Agriculture and Agri-Food Canada and the Natural Sciences and Engineering Research Council (NSERC) of Canada is acknowledged.

References

Abdus Sattar, Durrani S. K., Mahmood, F., Ahmad, A. and Khan, I. (1989) Effect of soaking and germination temperature on selected nutrients and antinutrients of mungbean. *Food Chemistry* **34**, 111–120.

Acikgoz, E., Katkat, A. V., Omeroglu, S. and Okan, B. (1985) Mineral elements and amino acid concentrations in field pea and common vetch herbages and seeds. *J. Agronom. Crop Sci.* **155**, 179–185.

Allen, O. N. and Allen, E. K. (1981) *The Leguminosae*. University of Wisconsin Press, Madison, WI.

Andrieu, J., Demarquilly, C. and Le Du, J. (1982) Valeur alimentaire de la plante entiere de feverole, de lupine, de pois et de soja sur pied et apres ensilage. *Bull. Tech. C.R.Z.V., Theix, I.N.R.A.* **47**, 19–26.

AOAC (1990) Official Methods of Analysis, 15th edn. Association of Official Analytical Chemists, Washington, DC.

Apata, D. F. and Ologhobo, A. D. (1994) Biochemical evaluation of some Nigerian legume seeds. *Food Chemistry* **49**, 333–338.

Askbrant, S. and Hakansson, J. (1984) The nutritive value of rapeseed meal, soya bean meal and peas for laying hens. *Swed. J. Agric. Res.* **14**, 101–110.

Bal, A. K. and Barimah-Asare, J. (1992) Legume–Rhizobium symbiosis in the shorelines of Newfoundland: N_2-fixation in beach pea root nodules. In *The Scientific Challenge of our Changing Enviroment*. eds.

J. Hall & M. Wadleigh. Canadian Global Change Program Incidental Report Series, *Report IR93-2*. Royal Society of Canada, Ottawa, ON, pp. 58–59.

Barrado, E., Pardo, R., Camarero, B., Tesedo, A. and Romero, H. (1994) Differentiation of legumes through elemental chemical composition using factor analysis. *Food Chemistry* **50**, 389–392.

Blackburn, S. (1978) Sample preparation and hydrolytic methods. In *Amino Acid Determination Methods and Techniques*, ed. S. Blackburn. Marcel Dekker, New York, pp. 7–37.

Cerning, J. and Guilhot, J. (1973) Changes in carbohydrate composition during maturation of wheat and barley kernel. *Cereal Chemistry* **50**, 220–225.

Dahl, L. K. (1972) Salt and Hypertension. *American Journal of Clinical Nutrition* **25**, 231–238.

Davidson, J. (1977) The nutritive value of field beans (*Vicia faba* L.) and field peas (*Pisum sativum*). In *Protein Quality from Leguminous Crops*, ed. Commission of the European Communities. ECSC-EEC-EAEC, Brussels–Luxembourg, pp. 243–250.

D'mello, J. P. F., Acamovic, I. and Walker, A. G. (1985) Nutritive value of jackbeans (*Canavalia ensiformis* (L.) DC.) for young chicks. *Trop. Agric. (Trinidad)*. **62**, 145–150.

Earle, F. R. and Jones, O. (1982) Analysis of seed sample from 113 plant families. *Econ. Bot*. **16**, 221–228.

Evans, R. J. and Bendemer, S. L. (1967) Nutritive value of legume seed proteins. *Journal of Agricultural Food Chemistry* **15**, 439–443.

FAO/WHO (1973) *Energy and protein requirements. Report of FAO Nutritional Meeting Series No*. **52**. FAO, Rome.

FAO/WHO/UNU (1985) *Energy and protein requrements. Report of a joint FAO/WHO/UNU Meeeting Series No*. **724**. WHO, Geneva.

Fernald, M. L. (1950) *Gray's Manual of Botany*, 8th edn. American Book Co., New York.

Hakansson, J. and Malmlof, K. (1984) The nutritive value of grass, clover and pea crop meals for growing pigs. *Swed. J. Agric. Res*. **14**, 45–51.

Henry, Y. and Bourdon, D. (1977) Utilization of legume seeds (field beans and peas) by the pig. In *Protein Quality from Leguminous Crops*, ed. Commission of the European Communities. ECSC-EEC-EAEC, Brussels–Luxembourg, pp. 252–272.

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

Jagadi, M. M., Rundgren, M. and Ogie, R. B. (1987) Chemical composition and protein quality of Tanzanian plant protein feedstuffs. *Ilca Bull*. **28**, 22–26.

Khalil, A. H. and Mansour, E. H. (1995) The effect of cooking, autoclaving and germination on the nutritional quality of faba beans. *Food Chemistry* **54**, 177–182.

Kumar, S., Kumar, S., Singh, G. K., Kumar, R., Bhatia, N. K. and Awasthi, C. P. (1991) Variation in quality traits of pigeonpea (*Cajanus cajan* L. mill sp.) varieties. *J. Food Technol*. **28**, 173–174.

Leconte, D. (1974) Pois fourrager plante entiere: evolution de la plante et choix de la date de recolte. Essai d'ensilage de pois fourrager. Document du Domaine experimental du Vieux Pin.I.N.R.A., pp. 7–15.

Lowry, O. W., Rosebrough, N. J., Farr, A. L. and Randall, R. J. (1951) Protein measurement with folin phenol reagent. *Journal of Biological Chemistry* **193**, 265–275.

Lund, S., Hakansson, J. and Eriksson, S. (1981) *Nutritive value of whole-crop peas for swine*. Report No. **57**, Swedish University of Agricultural Sciences, Department of Animal Nutrition, Uppsala, Sweden, pp. 8–12.

McCready, R. M., Guggolz, Slviera V. and Owens, H. S. (1950) Determination of starch and amylase in vegetables. *Analytical Chemistry* **22**, 1156–1158.

Meiners, C. R., Derise, N. L., Lall, H. C., Crews, M. G., Ritchey, S. J. and Murphy, E. W. (1976) The content of nine mineral elements in raw and cooked mature dry legumes. *Journal of Agricultural Food Chemistry* **24**, 1126–1130.

Meredith, F. I. and Thomas, C. A. (1982) Amino acid and elemental contents of lima bean seed. *Journal of Food Science* **47**, 2021–2025.

Mohan, V. R. and Janardhanan, K. (1995) Chemical analysis and nutritional assessment of lesser known pulses of the genus. *Mucuna*. *Food Chemistry* **52**, 275–280.

Moran, E. T., Summers, J. D. and Jones, G. E. (1968) Field peas as a major dietry protein source for the growing chick and laying hen with emphasis on high temperature steam pelleting as a practical means of improving nutritional value. *Can. J. Anim. Sci*. **48**, 47–55.

Nahapetian, A. and Bassiri, A. (1975) Changes in concentration and interrelationships of phytate, P, Mg, Cu, Zn in wheat during maturation. *Journal of Agricultural Food Chemistry* **23**, 1179–1182.

Nelson, N. (1944) A photometric adaptation of the Somogyi method for the determination of glucose. *Journal of Biological Chemistry* **15**, 375–380.

Oyenuga, V. A. (1968) *Nigeria's Foods and Feedingstuffs*, 3rd edn. Ibadan University Press, Ibadan, Nigeria.

Penke, B., Ferenczi, R. and Kovacs, K. (1974) A new acid hydrolysis method for determining tryptophan in peptides and proteins. *Analytical Biochemistry* **60**, 45–50.

Platt, B. S. (1980) Nutritive values of foods. In *Tables of Representative Values of Foods Commonly Used in Tropical Countries*. Medical Research Council, Special Report Series No. 302, Revised edn of SRS 253. Her Majesty's Stationary Office, London, pp. 10–12.

Salunkhe, D. K. and Kadam, S. S. (1989) *Handbook of World Food Legumes, Nutritional Chemistry, Processing Technology and Utilization*. CRC Press, Boca Raton, FL, pp. 23–50.

Salunkhe, D. K., Kadam, S. S. and Chavan, J. K. (1985) *Postharvest Biotechnology of legumes*. CRC Press, Boca Raton, FL, pp. 1–35.

SAS (1990) *Statistical Analysis System User's Guide*. Vols I and II, Version 6. SAS Institute, Inc., Cary, NC.

Shahidi, F. and Naczk, M. (1989) Effect of processing on the content of condensed tannins in rapeseed meals. *Journal of Food Science* **54**, 1082–1083.

Shahidi, F., Naczk, M., Hall, D. and Synowiecki, J. (1992) Insensitivity of the amino acids of canola and rapeseed to methanol–ammonia extraction and commercial processing. *Food Chemistry* **44**, 283–285.

Singh, U. and Jambunathan, R. (1980) Evaluation of rapid methods for the estimation of protein in chickpea (*Cicer arietinum*). *J. Sci. Food Agric*. **31**, 247–251.

Singh, U., Jambunathan, R., Saxena, K. and Subrahmanyam, N. (1990) Nutritional quality evaluation of newly developed high-protein genotypes of pigeon pea (*Cajanus cajan*). *J. Sci. Food Agric*. **50**, 201–209.

Swain, T. and Hillis, W. E. (1959) The phenolic constituents of Pruns domesticus. I. The quantitative analysis of phenolic constituents. *J. Sci. Food Agric*. **10**, 63–68.

Talbot, S. S. and Talbot, S. L. (1994) Numerical classification of the coastal vegetation of Attu Island, Aleutian Islands, Alaska.. *J. Vegetation Sci*. **5**, 867–876.

Trevino, J., Centeno, C. and Caballero, R. (1987) The chemical composition of pea plant parts as related to harvesting time. *Animal Feed Sci. and Tech*. **16**, 305–309.

Varnaite, R. N. (1984) Lignin content and other phenolic compounds in fodder plants of the genera vicia *Lathyrus* and medicago. *Lietuvos TSR mokslu akademijos darbai Cserija Biologijos Mokslai* **18**, 3–6.

Wanasundara, J. P. D. and Shahidi, F. (1994) Functional properties and amino acid composition of solvent-extracted faxseed meals. *Food Chemistry* **49**, 45–51.

Wills, R. B. H., Evans, T. J., Lim, J. S. K., Scriven, F. M. and Greenfield, H. (1984) Composition of Australian foods. 25. peas and beans. *Food Technol. Aust*. **36**, 512–514.

Wills, R. B. H., Lim, J. S. K. and Greenfield, H. (1987) Composition of Australian foods. 39. Vegetable fruits.. *Food Technol. Aust*. **39**, 488–491.

Zacharie, B. and Ronald, E. S. (1993) Nutrient composition, protein quality and antinutritional factors of some varieties of dry beans (*Phaseolus vulgaris*) grown in Burundi. *Food Chemistry* **47**, 159–167.