Pak. J. Bot., 41(6): 2739-2749, 2009.

EVALUATION OF BIOCHEMICAL AND PHYTOCHEMICAL COMPOSITION OF SOME GROUNDNUT VARIETIES GROWN IN ARID ZONE OF PAKISTAN

MUHAMMAD ASLAM SHAD[1*], HUMAYUN PERVEEZ[1], HAQ NAWAZ[1], HYDER KHAN[1], MUHAMMAD AMAN ULLAH[2]

[1]*Department of Chemistry, Bahauddin Zakariya University, Multan-60800, Pakistan*
[2]*Department of Statistics, Bahauddin Zakariya University, Multan-60800, Pakistan*
[*]*Corresponding author E-mail: shadaslam @ yahoo.com; Tel: 092-061-9210391*

Abstract

The biochemical composition and some phytochemicals in the seeds of 4 groundnut (*Arachis hypogaea* L.) varieties viz., Golden, Barri 2000, Mongphalla and Mongphalli 334 cultivated in arid zones of Pakistan, were determined. The biochemical analysis included ash, crude fat, total nitrogen, proteins and sugar contents. A statistically significant difference ($p<0.05$) was observed among the varieties regarding the ash, crude fat, water soluble proteins, salt soluble proteins and sugar contents. The four groundnut varieties were also found to be significantly different ($p<0.05$) on the basis of phytochemicals analysed including tannins (822±3.78 to 903±4.45 mg/100g), saponins (438±2.12 to 480±2.30 mg/100g), non-protein nitrogen (1.33±0.03 to 1.56±0.02 mg/100g), hydrogen cyanide (40.80±0.32 to 42.82±0.75 mg/100g), total phenolic acids (218±2.11 to 256±2.02 mg/100g), total phosphorus (700±3.62 to 889±3.84 mg/100g) and phytic acid (572±4.37 to 714±3.74 mg/100g). The results obtained from the present studies could be a source of valuable information and a guideline for the food scientists, researchers and even the nut consumers not only in Pakistan but all over the world.

Introduction

Legumes play an important role in human nutrition since these are rich sources of protein, calories, certain minerals and vitamins (Deshpande, 1992). Although, legumes are deficient in S-containing amino acids (Farzana & Khalil, 1999), these enhance the protein content of cereal-based diets and may improve the nutritional status of the cereal-based diets deficient in lysine (Amjad *et al.,* 2003). Among the legumes, nuts are a good source of oil containing higher amounts of unsaturated fatty acids as compared to saturated fatty acids (Sabate, 2003). However, legumes also contain some of the phytochemicals which have dual effect on human health. Some of these show their beneficial effects in lower amounts while some others may hinder efficient utilization, absorption or digestion of nutrients and thus reduce their bioavailability and nutritional quality (Liener, 1975).

The groundnut, often called as "The King of Oilseeds", is botanically known as *Arachis hypopgaea* and belongs to family Leguminosae. It is cultivated worldwide and is one of the major oilseed plants cultivated in Pakistan. In many areas of the world, particularly in Pakistan, this crop is cultivated in rain fed conditions. Groundnut is resistant to water stress conditions but drought conditions have adverse effects on the pod yield and seed grade (Stansell *et al*., 1976; Nageswara Rao *et al*., 1989). The effect of drought on the chemical composition of the groundnut seeds has been reported to be limited in the mid-season drought but significant in end-season drought (Conkerton *et al*., 1989; Musingo *et al*., 1989; Dwivedi *et al*., 1996). Umar (2006) reported that groundnut may be cultivated under such conditions along with potassium fertilization in order to minimize the adverse effects of water stress. In this regard, groundnut is a valuable crop

which may be a good source of income not only from the irrigated regions but also from the arid zones. In Pakistan, it is cultivated on vast area of about 50,700 hectars, 85% of which is cultivated only in Punjab. Groundnut is the rich source of fat ranging from 36 to 54% (Asibu, 2008). Groundnuts and groundnut butter are energy rich and nutritious foods, providing a valuable supply of a wide range of vitamins, minerals and dietary fibre (Jennette, 2003). Contrary to high calorific value, good mineral and nutritional composition, these also contain some phytochemicals, antinutrients, allergens and toxins which limit their frequent use as food supplements for long time (Fleischer *et al.,* 2003; Fasoyiro *et al.,* 2006).

A careful survey of literature revealed that little work has been done on the comparative studies of nutritional values and phytochemical composition of the seeds of groundnuts grown in Pakistan. Khalil & Chughtai (1983) investigated the chemical composition and nutritional quality of different groundnut cultivars grown in Pakistan. Their studies presented the valuable information about the proximate composition, minerals and amino acid score of these groundnut varieties. But no guidelines have been provided about the phytochemical composition of groundnuts cultivated in Pakistan. This paper hence presents the comparative studies on the biochemical and phytochemical analysis of four groundnut (*Arachis hypogaea* L.) varieties cultivated in arid zone of Pakistan.

Materials and Methods

Mature pods of four groundnut varieties viz., Golden, Barri 2000, Mongphalla and Mongphalli 334 recommended for cultivation in arid zones and irrigated regions of Pakistan, were collected from Barri Research Institute Chakwal, Punjab, Pakistan. The seeds were separated from the pod shells manually. The mature and immature seeds were further separated according to their size, shape and colour. The seeds were ground and stored in glass containers for the analysis of their biochemical and phytochemical composition.

Biochemical analysis

Ash contents: The ash contents were determined by standard method (Anon., 1990).

Sugars: The sugars were extracted from the finally powdered groundnut seeds following the method as described earlier (Shad *et al.*, 2009). Total sugars and reducing sugars were estimated by the methods of Travelyan & Harrison (1952) and Hulme & Narain (1931) respectively. Non-reducing sugars were calculated by difference. Qualitative analysis of sugars was carried by paper chromatography. The chromatograms were developed using ethyl acetate-pyridine-water (60:30:20; v/r) as solvent system and aniline phthalate as locating agent.

Total nitrogen and crude proteins: The contents of total nitrogen in each variety were estimated by using the Kjeldahl procedure (Anon., 1990). The percentage of crude proteins was calculated by multiplying the percent nitrogen by 6.25. The water soluble and salt [0.5 *M* $(NH_4)_2SO_4$] soluble protein contents were determined by Biuret method (Plummer, 1979).

Phytochemical analysis

Tannins: Tannins were extracted from defatted flour by the method of Horborn (1984). The tannins contents were determined by following the method of Makkar & Goodchild (1996). Thin layer chromatograms of different tannins extracted from each groundnut

variety, were developed using the solvent system chloroform-acetic acid (9:1, v/v) and the spots were visualised by spraying with Folin-Ciocalteu reagent followed by the fumigation with ammonia solution (Horborn, 1984).

Saponins: Saponins were extracted from defatted flour and determined by following the method as described by Anhawange *et al*., (2004).

Non-protein nitrogen: The contents of non-protein nitrogen (NPN) were extracted by the method as described by Chavan *et al*., (2003) and determined by using micro Kjeldahl procedure (Anon., 1990).

Hydrogen cyanide: The hydrogen cyanide (HCN) content of different groundnut varieties was determined by alkaline titration method (Anon., 1990). Ten grams of freshly ground sample of each variety was soaked in a mixture containing 200 ml of distilled water and 10 ml of phosphoric acid. The mixture was left for 12 hour to release bound hydrocyanic acid. The mixture was then distilled until 150 ml of the distillate was collected. Twenty ml of the distillate was taken into a conical flask containing 40 ml of distilled water. Eight ml of 6 *M* ammonium hydroxide and 2 ml of 5% potassium iodide solutions were added. The mixture was titrated with 0.02 *M* silver nitrate until faint but permanent turbidity was obtained. The cyanide content was calculated as:

$$1 \text{ mole } CN^- = 2 \text{ mole } AgNO_3$$

Phenolic acids: The free phenolic acids (FPA), esterified phenolic acids (EPA) and insoluble-bound phenolic acid (IBPA) fractions from defatted flour were extracted and determined using the method as described by Chavan *et al.*, (2003). The scheme for the extraction of different phenolic acids fractions has been presented in Fig. 1. The phenolic acids contents were expressed as mg tannic acid (instead of sinapic acid) equivalents per 100g sample. Total phenolic acid content was calculated as the sum of all fractions.

UV spectra: UV spectra of methanolic solutions phenolic acids viz. FPA, EPA and IBPA of each groundnut variety were recorded at the UV range (250-380 nm) using UV visible spectrophotometer (Optizen 2120 UV Plus, Mecasys, Koria).

TLC studies: The phenolic acids fractions (FPA, EPA and IBPA) from each peanut variety were used further for TLC studies. The chromatograms of different phenolic acids were developed by using silica gel as adsorbent and a solvent system containing chloroform-acetic acid (9:1, v/v). The plates were sprayed with Folin-Ciocalteu reagent followed by the fumigation of ammonia solution for the visualization of spots (Horborn, 1984).

Phosphorus contents: The total phosphorous (Pt), inorganic phosphorus (Pi), the fraction of phosphorus extractable in 1.2% aqueous HCl + 10% Na_2SO_4 (Pe), the fraction of Pe not precipitated by ferric ion (Ps), the fraction of Pe precipitated by ferric ion (Pp) and phytic acid content in the groundnut seeds were extracted and determined by following the method of Tangkongchitr *et al.,* (1981). All the determinations were done in triplicate and the phosphorus contents were expressed as milligram phosphorus/100g of dry sample.

Statistical analysis: The experimental results (means ± SD of three replicates) were analysed by one way analysis of variance (ANOVA; $p<0.05$) and the means were separated by Tukey's multiple range test using SPSS statistical software (version 17.0).

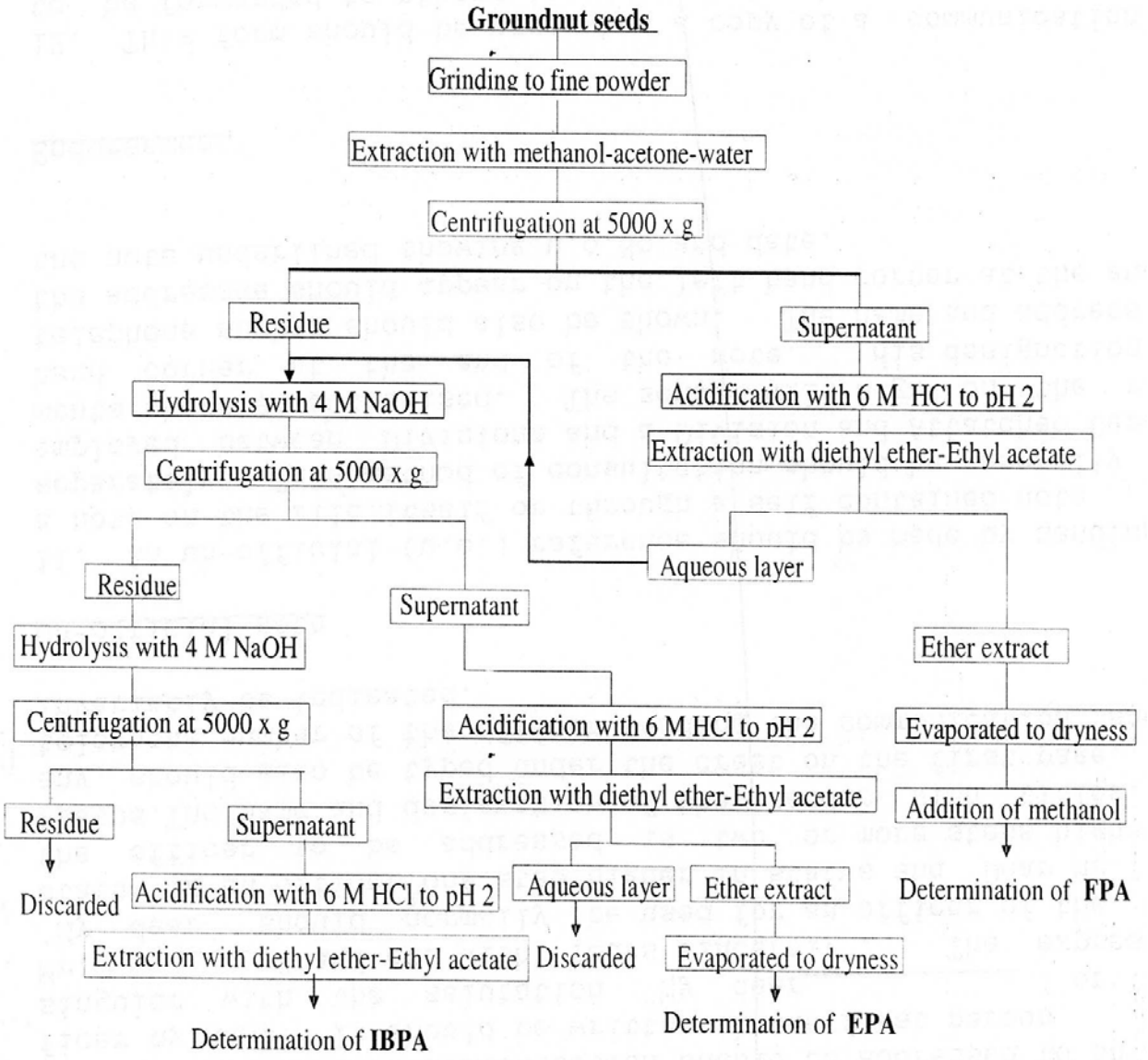

Fig. 1. Scheme for the extraction of different phenolic acid fractions from groundnut seeds.

Results and Discussion

The biochemical analysis of seeds of four groundnut varieties (Table 1) showed that the ash contents ranged from 2.70±0.03 to 3.03±0.02 g/100g which were found to be low as compared to those reported by Udayasekhara (1995) but comparable to those reported by Fasoyiro *et al.* (2006). The contents of total nitrogen, crude proteins and crude fat ranged from 4.84±0.75 to 5.18±0.35, 30.27±0.21 to 32.37±0.55 and 45.09±0.8 to 51.63±0.23 g/100g respectively. Among the four varieties, Mongphalli 334 was found to be high in total nitrogen (5.18±0.35 g/100g), crude protein (32.37±0.55 g/100g) and crude fat (51.63±0.23 g/100g) contents. The lower value of fat contents was observed in Barri 2000 (45.09±0.8 g/100g). Asibu (2008) reported a range of fat content (36-54%) in the seeds of 20 different groundnut varieties from Ghana. The fat contents in the present studies fall in this range. The crude fat content investigated in the present studies agreed with those reported by Atasie *et al*., (2009) while the protein content were low as compared to this report. The total nitrogen, crude protein and crude fat contents were found to be high as compared to the reports of Fasoyiro *et al.,* (2006).

Table 1. Biochemical composition of the seeds of different groundnut varieties.

Components (g/100g)	Golden	Barri 2000	Mungphalla	Mungphalli 334
Ash content	3.00 ± 0.04[a]	2.80 ± 0.02[b]	3.03 ± 0.02[a]	2.70 ± 0.03[c]
Crude fat	50.42 ± 1.02[a]	45.09 ± 0.8[b]	49.18 ± 2.10[a]	51.63 ± 0.23[a]
Total nitrogen	5.12 ± 0.19[a]	4.98 ± 0.26[a]	4.84 ± 0.75[a]	5.18 ± 0.35[a]
Crude protein	32.00 ± 1.19[a]	31.13 ± 1.63[a]	30.24 ± 4.69[a]	32.37 ± 2.19[a]
Water soluble proteins	2.50 ± 0.04[ab]	2.23 ± 0.23[b]	2.63 ± 0.13[a]	2.60 ± 0.05[a]
Salt soluble proteins	15.95 ± 0.18[b]	15.00 ± 0.09[c]	16.38 ± 0.21[a]	15.60 ± 0.11[b]
Total sugars	8.11 ± 0.04[b]	7.64 ± 0.06[c]	8.30 ± 0.12[ab]	8.31 ± 0.04[a]
Reducing sugars	1.87 ± 0.10[ab]	1.97 ± 0.08[a]	1.74 ± 0.05[ab]	1.64 ± 0.11[b]
Non-reducing sugars	6.24 ± 0.06[b]	5.67 ± 0.02[c]	6.56 ± 0.07[a]	6.67 ± 0.07[a]

The means expressed with same letter, in each row, are not significantly different at p≤0.05, using Tukey's multiple range test.

Table 2. Phytochemical components of seeds of different groundnut varieties.

Components (mg/100g)	Golden	Barri 2000	Mungphalla	Mungphalli 334
Tannins	903 ± 4.45[a]	822 ± 3.78[d]	860 ± 2.61[c]	893 ± 3.36[b]
Saponins	480 ± 2.30[a]	438 ± 2.12[c]	465 ± 3.24[b]	476 ± 2.69[a]
Non-protein nitrogen (% of total N)	1.56 ± 0.02[a]	1.44 ± 0.09[ab]	1.33 ± 0.03[b]	1.39 ± 0.06[b]
Hydrogen cyanide	42.2 ± 0.42[a]	41.78 ± 0.56[ab]	40.80 ± 0.32[b]	42.82 ± 0.75[a]
Phenolic acids				
Free	97 ± 1.11[b]	100 ± 1.03[b]	112 ± 1.14[a]	115 ± 1.25[a]
Esterified	78 ± 1.23[b]	80 ± 1.33[b]	97 ± 1.08[a]	100 ± 1.32[a]
Insoluble-bound	43 ± 0.24[a]	43 ± 0.55[a]	38 ± 0.87[c]	41 ± 0.98[b]
Total	218 ± 2.58[c]	223 ± 3.05[c]	247 ± 3.09[b]	256 ± 3.55[a]

The means expressed with same letter, in each row, are not significantly different at p≤0.05, using Tukey's multiple range test.

The contents of water soluble and salt soluble protein fractions ranged from 2.23±0.23 to 2.63±00.13 g/100g, and 15.00±0.09 to 16.38±0.21 g/100g respectively. These contents were found highest in Mongphalla but low in Barri 2000. The water soluble proteins (WSP) have been found to be effective scavengers of superoxides and hydrogen peroxide (Okada & Okada, 1998). The considerable amount of WSP in groundnuts seeds may be helpful in preventing the oxidative damage in the body. The contents of total sugar, reducing sugar and non-reducing sugar ranged from 7.64±0.06 to 8.30±0.12, 1.64±0.11 to 1.97±0.08 and 5.67±0.21 to 6.67±0.24 g/100g respectively. Barri 2000 contained lowest values of total sugars and non-reducing sugar but showed higher values for reducing sugars contents. Mongphalli 334 was high in total and non-reducing sugars but low in reducing sugars contents. Qualitatively three sugars viz., glucose, fructose and sucrose were found to be present in each variety.

The studies on some phytochemicals in the defatted flour of groundnut seeds (Table 2) showed that total tannins contents in different groundnut varieties ranged from 822±3.78 to 903±4.45mg/100g. These were found to be high in Golden and lowest in Barri 2000. The results were found to be lower than those reported for groundnut seeds (Fasoyiro *et al.,* 2006) but were found to be comparatively higher than those reported by Udayasekhara (1995). In the TLC studies of tannins, six spots of different Rf values were obtained in case of each variety (Fig. 2) indicating the presence of six types of tannins in groundnut seeds. Tannins are the oligomeric higher molecular weight polyphenolic compounds occurring naturally in plants. Due to their binding ability with protein and carbohydrates, tannins can inhibit digestive enzymes and reduce the bioavailability of different proteins (Hagerman *et al.,* 1992; Reed, 1995).

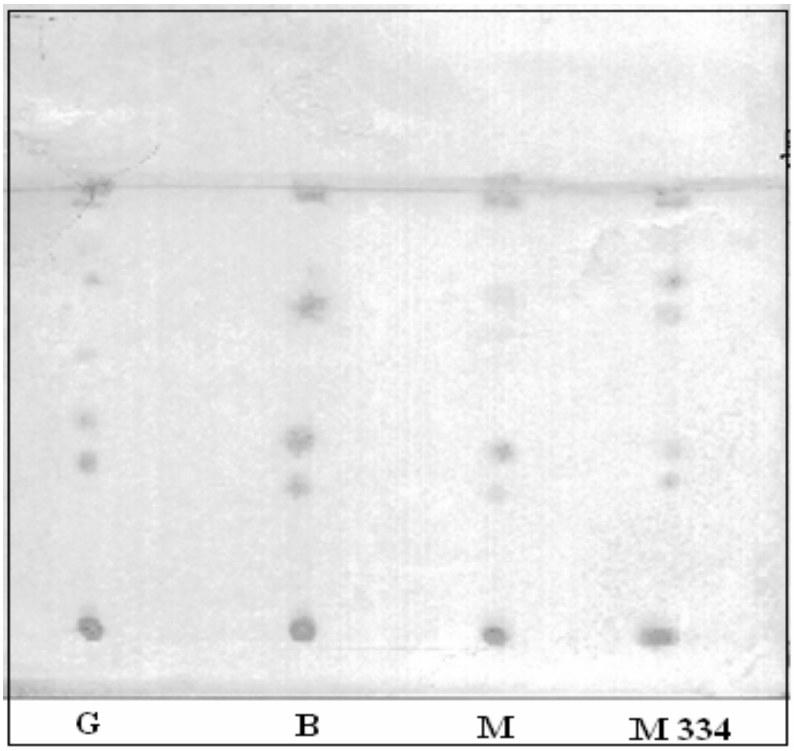

Fig. 2. TLC chromatograms of tannins in different groundnut varieties.
G; Golden, B; Barri 2000, M; Mongphalla, M 334; Mongphalli 334,
Adsorbent material: Silica gel, Solvent system; chloroform-acetic acid (9:1 v/v), Locating reagent; Folin-Ciocalteu reagent.

The saponins contents ranged from 438±2.12 to 480±2.30 mg/100g and were found to be high in Golden and low in Barri 2000. Saponins have both beneficial and adverse effects on human health. Contrary to their hypocholesterolemic property (Oakenfull & Sidhu, 1990), saponins also show hemolytic activity by reacting with the sterols of erythrocyte membrane (Baumann *et al.,* 2000).

The non-protein nitrogen (NPN) content ranged from 1.33±0.03 to 1.56±0.02 % of total N and was found to be significantly different ($p<0.05$). The NPN content was maximum in Golden (1.56%) followed by Barri 2000 (1.44%), Mongphalli 334 (1.39%) and Mongphalla (1.33%). The results were low as compared to those reported earlier for beach pea seeds (Chavan *et al.,* 2003) and for chickpea and pigeon pea (Singh & Jambunathan, 1982). Chizzotti *et al*., (2008) investigated the effect of NPN on performance, digestibility, ruminal characteristics and microbial efficiency in crossbred steers and reported that the dietary intake of NPN up to 46.5% of total N has no significant effect on their growth performance or ruminal protein synthesis. The present investigations suggest that the dietary intake of groundnut seeds may have no significant effect on the growth performance of the individuals.

The contents of HCN ranged from 40.80±0.32 to 42.82±0.75 mg/100g. A significant difference was found in HCN content among the four groundnut varieties ($p<0.05$). HCN is present in plants in the form of cyanogenetic glucosides and is toxic due to the cyanide ion whose toxic properties are shared by all the soluble inorganic cyanide salts present in the samples (Smith *et al.,* 2003). The results of present studies indicate high levels of HCN present in raw seeds of groundnut varieties as compared to those of some wild plants (Nkafamiya *et al.,* 2007). The continuous exposure of HCN through diet may lead to pancreatic diabetes, Vitamin B_{12} deficiency and decreased uptake of iodine by thyroid glands which may further lead to goiter (Sharma, 1993; Kamalu, 1995). Jansz &

Uluwaduge (1997) reported that people eating foods containing low level of cyanide for long time developed damage to the central nervous system and the thyroid gland. The hydrogen cyanide content can be reduced by different heat processing methods (Dingyuan *et al.,* 2003). It is therefore suggested that the groundnut should be roasted before eating to reduce its possible toxic effects.

Among the phenolic acids fractions, the contents of free phenolic acids (FPA), esterified phenolic acids (EPA) and insoluble-bound phenolic acid (IBPA) ranged from 97±1.11 to 115±1.25, 78±1.23 to 100±1.32 and 38±0.87 to 43±0.55 mg/100g respectively. The total phenolic acids contents, obtained from the sum of free, esterified and insoluble-bound fractions, ranged from 218±2.11 to 256±2.02 mg/100g. A statistically significant difference in the content of phenolic acid fractions was observed among the groundnut varieties ($p<0.05$). Mongphalla and Mongphalli 334 contained higher FPA and EPA contents but lower IBPA contents as compared to Golden and Barri 2000. In the present investigations FPA content were found to be high in relation to the EPA and IBPA content in each groundnut variety. The total phenolic acid contents were found to be high in Mongphalli 334. The results were in agreement with those reported earlier for green pea and Canadian grass pea and Indian grass pea (Chavan *et al.,* 1999b). The results were found to be four folds lower than those reported for beach pea seeds (Chavan *et al*., 2003). On the other hand, these results were found to be very high as compared to the range reported in literature for legume flours such as mung beans, field peas, lentils, faba beans, pegion peas, nava beans, lupins, lima beans, chick peas and cowpeas ranging from 1.80 to 16.30 mg/100g (Sosulski & Dabrowski, 1984).UV spectra of different phenolic acids (Fig. 3) explained that all the phenolic acids in each groundnut variety showed maximum absorbance at the same wavelength (280 nm) which resembles to that reported for phenolic acids in beach pea (Chavan *et al.,* 2003). Phenolic acids and their derivatives occurring in relatively high concentrations in certain oilseeds and legume seeds are responsible for the development of adverse tastes and colours in food products and decreased protein nutritive value. The soluble phenolic constituents also have been investigated in oilseed flours such as peanut, soybean and cottonseed (Krygier, *et al.,* 1982).

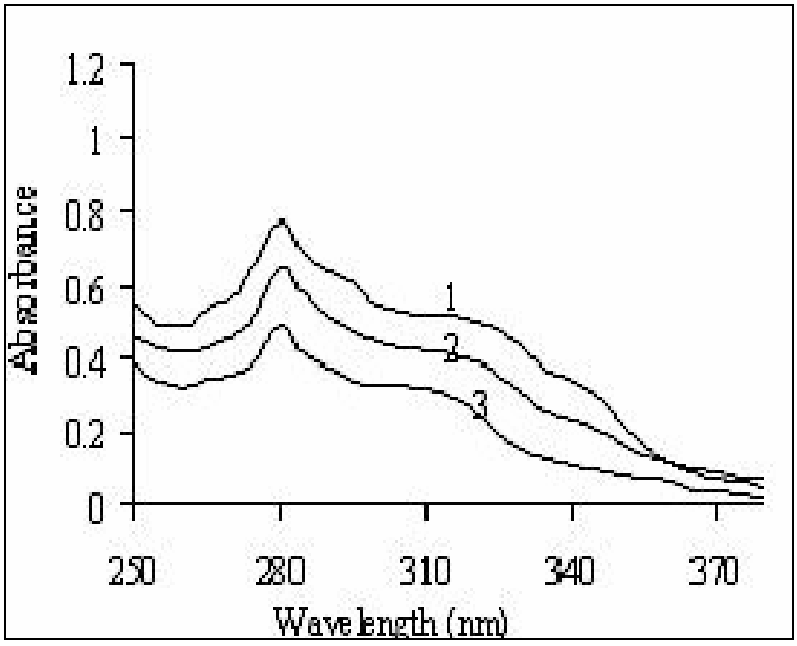

Fig. 3. Typical UV spectra of methanolic solutions of different phenolic acid fractions in the seeds of Barri 2000. (1) Insoluble-bound phenolic acids, (2) Free phenolic acids and (3) Esterified phenolic acids, Wavelength range 250-380 nm.

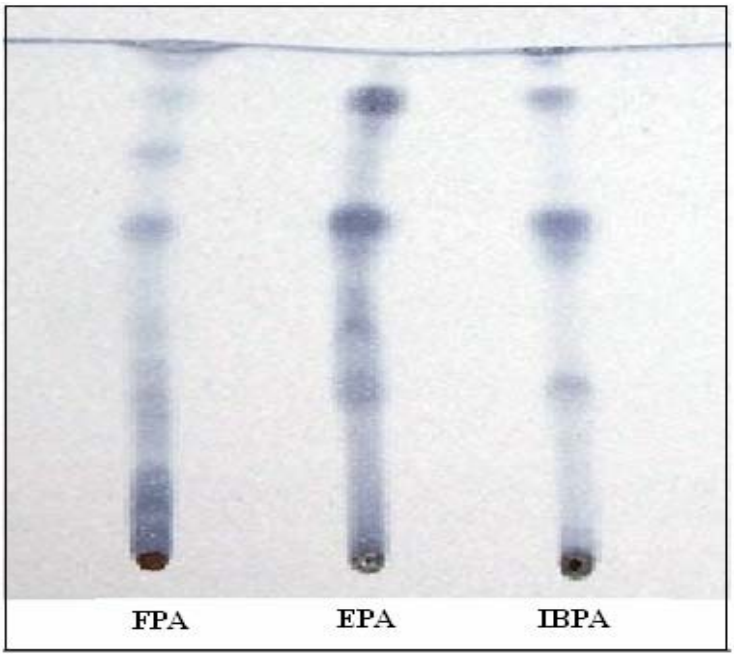

Fig 4. Typical TLC chromatogram of phenolic acids in seeds of Barri 2000. FPA: Free phenolic acids, EPA: Esterified phenolic acids, IBPA: Insoluble-bound phenolic acids. Adsorbent material: Silica gel, Solvent system: chloroform-acetic acid (9:1; v/v), Locating reagent: Folin-Ciocalteu reagent.

UV spectra of phenolic acid fractions indicate that all of the phenolic acid fractions in each groundnut variety showed maximum absorbance at 280 nm. A representation of typical UV spectra of different phenolic acid fractions has been given in Fig. 3. The results agreed with those reported by Chavan *et al*., (2003) for beach pea seeds. TLC studies of different fractions of phenolic acids showed that eight spots of different Rf. values were observed for FPA while seven spots for EPA and six spots for IBPA in case of each variety (Fig. 4). The results clearly showed that each of the groundnut variety had several phenolic acid components but there is no difference in the number of phenolic acid components among the four groundnut varieties. Each of the four groundnut varieties contained higher number of phenolic acid components in the FPA fraction followed by EPA and IBPA fraction.

The quantitative analysis of phosphorus and its different fractions have been presented in Table 3. The total phosphorus contents ranged from 700±3.62 to 889±3.84 mg/100g, fractionated as inorganic phosphorus from 168±2.01 to 235±1.73 mg/100g, phosphorus extractable in 1.2% HCl and 10% Na_2SO_4 from 262±3.21 to 327±2.51 mg/100g, phosphorus precipitated with ferric ions from 161±1.58 to 201±1.91mg/100g and the phosphorus not precipitated with ferric ions from 100±1.21 to 128±1.18 mg/100g. The phytic acid contents ranged from 572±4.37 to 714±3.74 mg/100g. The four groundnut varieties were found to be statistically different ($p<0.05$) on the basis of total phosphorus and its different fractions and phytic acid contents. Mongphalli 334 was found to be high in each type of phosphorus. Low phosphorus contents were observed in Golden. The total phosphorus and phytic acid contents were found to be comparable to those reported earlier in different groundnut varieties (Udayasekhara, 1995). These results were found to be two folds higher than those reported for beach pea seeds (Chavan *et al.,* 2003).

Table 3. Phosphorus contents in the seeds of different groundnut varieties.

Fractions of phosphorus	Golden	Bari 2000	Mongphalla	Mongphalli 334
Inorganic	168 ± 2.01^{b}	169 ± 1.98^{b}	233 ± 1.49^{a}	235 ± 1.73^{a}
Extractable in acid + salt	262 ± 3.21^{c}	267 ± 1.45^{c}	317 ± 2.85^{b}	327 ± 2.51^{a}
Precipitated by Fe^{3+}	100 ± 1.21^{b}	100 ± 1.75^{b}	126 ± 1.66^{a}	128 ± 1.18^{a}
Non-precipitated by Fe^{3+}	161 ± 1.58^{d}	166 ± 2.11^{c}	191 ± 1.34^{b}	201 ± 1.91^{a}
Total phosphorus	700 ± 6.62^{c}	706 ± 3.35^{c}	876 ± 2.40^{b}	889 ± 3.84^{a}
Phytic acid	572 ± 4.37^{d}	589 ± 2.86^{c}	678 ± 6.02^{b}	714 ± 3.12^{a}

The means expressed with same letter, in each row, are not significantly different at $p \leq 0.05$, using Tukey's multiple range test.

Conclusion

The present investigations suggest that the groundnut seeds are rich source of protein, sugars and oil and thus provide higher calorific score as compared to most of the other legumes. No significant difference ($p<0.05$) was found to be present among the groundnut varieties regarding the nitrogen and protein content. Barri 2000 contains comparatively low fat content and is thus favourable groundnut variety concerning low fat diets. Along with their good nutritional composition, groundnut seeds also contain considerable amounts of phytochemicals *viz*., tannins, saponins, non protein nitrogen, HCN, phenolic acids, phosphorus and phytic acid. The four groundnut varieties show a statistically significant difference ($p<0.05$) in their phytochemical compositions. Golden and Barri 2000 constitute lower amounts of phytochemicals as compared to other two varieties. The variation in the investigated parameters among the present groundnut varieties as well as those investigated by other workers may be due to genetic and climatic variations or due to different agronomic conditions. It is therefore, concluded that groundnut seeds have good nutritional composition along with some phytochemicals and might be recommended for different food supplementations in processed form in order to reduce the antinutritional effects of these phytochemicals.

Acknowledgement

The authors are grateful to Barri Research Institute Chakwal, Punjab, Pakistan for providing the seeds of groundnut varieties.

References

Amjad, I., I.A. Khalil and H. Shah. 2003. Nutritional yield and amino acid profile of rice protein as influenced by nitrogen fertilizer. *Sarhad J. Agric*., 19: 127-134.

Anhawange, B.A., V.O. Ajibola and S.J. Oniye. 2004. Chemical studies of seeds of Moronga oleifera Lam and *Detarium microcarpum* Guill and Sperr. *J. Biol. Sci*., 4(6): 711-715.

Anonymous. 1973. British Pharmacopeia. University printing House; Cambridge, UK.

Anonymous. 1990. *Official Methods of Analysis* (15th ed.). Arlington: Association of Official Analytical Chemists.

Asibu, J.Y., R. Akromah, H. K. Adu-Dapaah and O. Safo-Kantanka. 2008. Evaluation of nutritional quality of groundnut (*Arachis hypogaea* L.) from Ghana. *AJFAND,* 8(2): 133-150.

Atasie, V.N., T. F, Akinhanmi and C.C. Ojiodu. 2009. Proximate analysis an physicochemical properties of Groundnut (*Arachis hypogaea* L.). *Pak. J. Nuti*., 8(2): 194-197.

Baumann, E., G. Stoya, A. Völkner, W. Richter, C. Lemke and W. Linss. 2000. Hemolysis of human erythrocytes with saponin affects the membrane structure. *Acta Histochem.*, 102: 21-35.

Chavan, U.D., D.B. Mckenzei, R. Amarowicz and F. Shahidi. 2003. Phytochemical components of beach pea (*Lathyrus maritimus* L.). *Food Chem*., 81: 61-71.

Chavan, U.D., F. Shahidi, A.K. Bal and D.B. McKenzie. 1999b. Physico-chemical properties and nutrient composition of beach pea (*Lathyrus maritimus* L.). *Food Chem.*, 66: 43-50.

Chizzotti, F.H.M., O.G. Pereira, L.O. Tedeschi, S.C. Valadares Filho, M.L. Chizzotti, M.I. Leao and D.H. Pereira. 2008. Effect of dietary nonprotein nitrogen on performance, digestibility, ruminal characteristics and microbial efficiency in crossbred steers. *J. Anim. Sci.,* 86: 1173-1181.

Conkerton, E.J., L.F. Ross, D.J. Daigle, C.S. Kvien and C. Mc-Combs. 1989. The effect of drought stress on peanut seed composition. II. Oil, protein and minerals. *Oleagineux*, 44: 593-599.

Deshpande, S.S. 1992. Food legumes in human nutrition: A personal perspective. *Rev. Food Sci. Nutr.*, 32: 333-363.

Dingyuan, F., S. Yingran and E.R. Chavez. 2003. Effectiveness of different processing methods in reducing hydrogen cyanide content of flaxseed. *J. Sci. Food Agric.,* 8: 836-841.

Dwivedi, S.L., S.N. Nigam, R.C. Nageswara Rao, U. Singh and K.V.S. Rao. 1996. Effect of drought on oil, fatty acids and protein contents of groundnut (*Arachis hypogaea* L.) seeds. *Field Crops Res*., 48: 125-133.

Farzana, W. and I.A. Khalil. 1999. Protein quality of tropical food legumes. *J. Sci. Technol*., 23: 13-19.

Fasoyiro, S.B., S.R. Ajibade, A.J. Omole, O.N. Adeniyan and E.O. Farinde. 2006. Proximate, minerals and antinutritional factors of some underutilized grain legumes in south-western Nigeria. *Nutr. Food Sci*., 36: 18-23.

Fleischer, D.M., M.K.C. Walker, L. Christie, A.W. Burks and R.A. Wood. 2003. The natural progression of peanut allergy: Resolution and the possibility of recurrence. *J. Aller. Clinic. Immunol*., 112: 183-189.

Hagerman, A.E., C.T. Robbins, Y. Weerasuriya, T.C. Wilson and C. McArthur. 1992. Tannin chemistry in relation to digestion. *J. Range Manage*., 45: 57-62

Harborne, J.B. 1984. *Phytochemical methods* (2nd ed. pp. 87-88). New Yark: Chapman and Hall.

Hulme, A.C. and R. Naraian. 1931. The ferricyanide method for the determination of reducing sugars. A modification of the Hagedorn-Jensen-Hanes Technique. *Biochem. J.,* 25: 1051-61.

Jansz, E.R. and D.I. Uluwaduge. 1997. Biochemical aspects of cassava (*Manihot esculenta Crantz*) with special emphasis on cyanogenic glucosides - A review. *J. Natn. Sci. Coun. Sri Lanka*, 25(1): 1-24.

Jennette, H. 2003. The beneficial role of peanuts in the diet-Part 2. *Nutr. Food Sci*., 33: 56-64.

Kamalu, B.P. 1995. The adverse effects of long term cassava (*Manihot eaculenta Crantz*) consumption, *Intl. J. Food. Sci. Nutr.,* 46: 65-93.

Khalil, J.K. and M.I.D. Chughtai. 1983. Chemical composition and nutritional quality of five peanut cultivars grown in Pakistan. *Plant Food Hum. Nutri.*, 33(1): 63-70.

Krygier, K., F. Sosulski and L. Hogge. 1982. Free, Esterified, and Insoluble-Bound Phenolic Acids.1. Extraction and purification procedure. *J. Agric. Food Chem.,* 30: 330-334.

Liener, I.E. 1975. Effects of antinutritional and toxic factors on the quality and utilization of legume proteins. In: *Protein Nutritional Quality of Foods and Feeds, Part 2: Quality Factors* (pp. 523-50). (Ed.): M. Friedman. New York: Marcel Dekker.

Makkar, H.P.S. and A.V. Goodchild. 1996. Quantification of Tannins: *A Laboratory Manual*. International Centre for Agricultural Research in the Dry Areas, Aleppo, Syria.

Musingo, M.N., S.M. Basha, T.H. Sanders, R.J. Cole and P.D. Blankenship. 1989. Effect of drought and temperature stress on peanut (*Arachis hypogaea* L.) seed composition. *J. Plant Physiol*., 134: 710-715.

Naczk, M., L.L. Diosady and L.J. Rubin. 1986. The phytate and complex phenol content of meals produced by alkanol-ammonia/hexane extraction of canola. *Lebensmittal Wissenscizafre und Technologie*, 19: 13-16.

Nageswara Rao, R.C., J.H. Williams and M. Singh. 1989. Genotypic sensitivity to drought and yield potential of peanut. *Agron. J*., 81: 887-893.

Nahapetian, A. and A. Bassiri. 1975. Changes in concentration and interrelationships of phytate, P, Mg, Cu, Zn in wheat during maturation. *J. Agric. Food Chem.*, 23: 1179-1182.

Nkafamiya, I.I., U.U. Modibbo, A.J. Manji and D. Haggai. 2007. Nutrient content of seeds of some wild plants. *African J. Biotechnol*., 6: 1665-1669.

Oakenfull, D. and G.S. Sidhu. 1990. Could saponins be a useful treatment for hypercholesterolemia? *European J. Clin. Nutr*., 44: 79-88.

Okada, Y. and M. Okada.1998. Scavenging effect of water soluble proteins in broad bread on free radical and active oxygen species. *J. Agric. Food Chem.,* 46: 401-406.

Plummer, D.T. 1979. *An introduction to practical biochemistry* (2nd Ed.). New Delhi, India: Tata McGraw-Hill Publ. Comp. Ltd.

Pons, W.A. and J.D. Guthrie. 1946. Determination of inorganic phosphorus in plant materials. *Indust. Eng. Chem. Anal.*, 18: 184-186.

Reed, J.D. 1995. Nutritional toxicology of tannins and related polyphenols in forage legumes. *J. Anim. Sci.,* 73: 1516-1528.

Sabate, J. 2003. Nut composition and body weight. *Am. J. Clin. Nutr*., 78: 647S-650S.

Shad M.A., H. Pervez, Z.I. Zafar, M. Zia-ul-Haq and H. Nawaz. 2009. Evaluation of biochemical composition and physicochemical parameters of oil from seeds of desi chickpea varieties cultivated in arid zone of Pakistan. *Pak. J. Bot.*, 41(2): 655-662.

Sharma, R.P. 1993. *Cyanide containing foods and potential for fetal malformations*. In: Dietary Factors and Birth Defects (Ed.): R. P. Sharma. Pacific Division, AAAS, San Francisco, CA.

Singh, U. and R. Jambunathan. 1982. Distribution of seed protein fraction and amino acids in different anatomical parts of chick pea (*Cices arietinum* L.) and pegion pea (*Cajans cajan* L.) *Plant Foods Human Nutr*., 31: 347-354.

Smith, M.A.D., S. Buckett and N.A. Waters. 2003. *Qualitative Determination of Cyanogenetic Glucoside in Plant Foodstuff* (pp. 40-41). New Yark: Academic Press.

Sosulski, F.W. and K.J. Dabrowski. 1984. Composition of free hydrolysable phenolic acids in flours and hull of ten leguminous species. *J. Agric. Food Chem*., 32: 131-133.

Stansell, J.R., J.L. Shepard, J.E. Pallas, R.R. Bruce, N.A. Minton, D.K. Bell and L.W. Morgan. 1976. Peanut responses to soil water variables in the Southeast. *Peanut Sci*., 3: 44-48.

Tangkongchitr, U., P.A. Seib and R.C. Hoseney. 1981. Phytic acid 1. Determination of three forms of phytic acid in flour, dough and bread. *Cereal Chem.*, 58: 226-228.

Travelyan, W.E. and J.S. Harrison. 1952. Fractionation and micro determination of cell carbohydrates. *Biochem. J*., 50: 298-310.

Udayasekhara, P.U. 1995. Effect of germination on tannin, mineral, and trace element composition of groundnut varieties. *J. American Oil Chem. Soc*., 72: 477-480.

Umar, S. 2006. Alleviating adverse effects of water stress on yield of sorghum, mustard and groundnut by potassium application. *Pak. J. Bot.*, 38(5): 1373-1380.

(Received for publication 23 June 2009)