Pak. J. Bot., 43(6): 2829-2833, 2011.

DETERMINATION OF MACRO AND MICRONUTRIENTS AND NUTRITIONAL PROSPECTS OF SIX VEGETABLE SPECIES OF MARDAN, PAKISTAN

JAVID HUSSAIN[1,2*], NAJEEB UR REHMAN[1,2], ABDUL LATIF KHAN[1,3], HIDAYAT HUSSAIN[2], AHMED AL-HARRASI[2], LIAQAT ALI[2], FARHANA SAMI[1], AND ZABTA KHAN SHINWARI[4]

[1]Department of Chemistry, Kohat University of Science & Technology, Kohat, Pakistan
[2]Department of Biological Sciences and Chemistry, College of Arts & Sciences, University of Nizwa, Oman
[3]School of Applied Biosciences, Kyungpook National University, Daegu Republic of Korea
[4]Department of Biotechnology, Quaid-i-Azam University, Islamabad, Pakistan

Abstract

This study was carried out to assess the nutritional and mineral composition of selected vegetables, which are commonly used as food in Pakistan. *Abelmoschus esculentus, Solanum melongena*, *Cucurbita moschata, Allium sativum*, *Momordica charantia* and *Portulaca oleracea* were collected form Mardan (Pakistan) and subjected to nutrient analysis. Nutrient analysis (total proteins, fats, carbohydrates, ash, energy value and moisture contents) of vegetable species were determined according to AOAC methods. Macro viz. calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), and phosphorus (P) and micro viz. iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), nickel (Ni) and selenium (Se) elements were analyzed using Atomic Absorption Spectrometric method. The moisture (wet and dry basis), ash, fats, fibers, proteins, energy value (305.9-382.6 Kcal/100g) and carbohydrates of these vegetable species were found in the range of 62.9-92.7, 5.4-7.7, 3.1-23.1, 0.3-8.3, 10.2-22.5, 7.7-16.9, and 51.3-80.2% respectively. The micronutrients including Fe, Zn, Mn, and Cu were found to be in the range, 6.2-24.1, 0.2-11.7, 0.6-16.7, and 0.1-70 ppm respectively. The results of macronutrients obtained having values of Ca (90-1850 ppm), Mg (94-571 ppm), K (2078-4010 ppm), Na (2-170 ppm), and P (250-1532 ppm) respectively. The quantity of Ni and Se were found negligible in these vegetables. The results indicate that all these vegetables have the potential to provide essential nutrients to the human beings. *Momordica charantia* and *Allium sativum* were found to be a good source of proteins, fats, carbohydrates, hence capable of providing energy to the consumer. Both these species were found significantly useful in terms of minerals sources, particularly Ni, K, P, Zn, Cu, and Mn.

Introduction

Increasing population of the world has doubled the food demands and inundated the available land resources. Alongside other food alternatives, vegetables are considered cheap source of energy (Alertor *et al*., 2002; Hussain *et al*., 2009). Vegetables are rich sources of essential biochemicals and nutrients such as carbohydrates, carotene, protein, vitamins, calcium, iron, ascorbic acid and palpable concentration of trace minerals (Salunkhe & Kadam, 1995). These vegetables will continue to remain a basic source of energy for developing countries. More cheaper and qualitative food alternatives have been stressed and recognized by many stakeholders from national's governments to international agencies like Food and Agricultural Organization (FAO) (Anon, 1993; Tiaga *et al*., 2008; Khan *et al*., 2003).

Carbohydrates, fats and proteins are the essential nutrients of life. The quality and quantity of proteins in the seeds are basic factors and important for the selection of plants for nutritive value, systematic classification and plant improvement programs (Nisar *et al*., 2009). Besides these biochemicals, the moisture, fibers, and ash contents and the energy values of individual vegetable and plant species have also been regarded important to the human health and the soil quality (Hussain *et al*., 2010). Nutrient analysis of edible fruits and vegetables plays a crucial role in assessing their nutritional significance. The considerable use of vegetable species by the local people in their diet motivated us to carry out the present nutrient analysis (Pandey *et al*., 2006; Nasib *et al*., 2008). Among these vegetables, *S. melongena* is used as a food crop, but its medicinal importance also makes it a valuable addition to the diet. In particular it also helps to lower blood cholesterol levels and is suitable as part of a diet to regulate high blood pressure (Lawande *et al*., 1998). *A. sativum* L. is reported for anticancer activity, anthelmintic, antiasthmatic, anticholesterolemic, antiseptic, antispasmodic, cholagogue, diaphoretic, diuretic, expectorant, febrifuge, stimulant, stings, stomachic, tonic, and vasodilator (Duke & Ayensu, 1985; Grieve, 1984). *M. charantia* has been used in various Asian traditional medicine systems for a long time (Launert, 1981). *P. oleracea* is antibacterial, antiscorbutic, depurative, diuretic and febrifuge (Bown, 1995; Chopra & Nayar, 1986). *A. esculentus* is used in the treatment of catarrhal infections, ardor urinae, dysuria and gonorrhoea. The seeds are antispasmodic, cordial and stimulant (Chiej, 1984; Facciola, 1990). On the basis of importance and proliferate use of the aforementioned vegetable species, these were selected to evaluate their biochemical and nutrients composition.

Materials and Methods

Plants collection: All the vegetable species were collected from various areas of Mardan, KPK, Pakistan. The woody part and dirt were removed from the vegetables prior to analysis and a composite sample analyzed for nutrient analysis and minerals. The details of each vegetable species, in respect of their local names, parts used and status are elaborated in Table 1.

Sample treatment: The samples were manually washed with distilled water and residual moisture evaporated at room temperature. Then these were oven dried in paper envelope at 55ºC for 24 hours (Abuye *et al*., 2003), ground into fine powder using pestle and mortar, and sieved through 20-mesh sieve. The dried powdered samples were used for the analyses. For moisture content determination, however, fresh samples were used.

***Corresponding author: javidhej@yahoo.com**

Table 1. Vegetables collected for the study and pattern of local use.

Species name	Family name	Parts used	Status
A. esculentus	Malvaceae	Fruit	Cultivated
S. melongena	Solanaceae	Fruit	Cultivated
C. moschata	Cucurbitaceae	Fruit	Gardening
A. sativum	Alliaceae	Flashy leaves	Cultivated
M. charantia	Cucurbitaceae	Fruit	Cultivated
P. oleracea	Portulacaceae	Leaves	Wild

Nutritional analysis: By using the standard methods of the Association of the Analytical Chemists (AOAC), determination of moisture, ash, and crude fibers (on dry basis) was carried out (Anon, 2000). The determination of proteins in terms of nitrogen was done by micro Kjeldahl method (Kjeldahl, 1983). The nitrogen value was converted to protein by multiplying to a factor of 6.25. The lipid content of the samples was done using Soxhlet type of the direct solvent extraction method. The solvent used was petroleum ether (boiling range 40-60ºC) (Anon, 2007). The crude fibre was also determined by the method described by (Boussama, 1999). The energy values (kcal/100 g) were determined by multiplying the values of carbohydrates, lipids and proteins by a factor of 4, 9, and 4 respectively, and taking the sum expressed in kilocalories (Okwu & Morah, 2004; Hussain *et al*., 2010). The total carbohydrates were determined by difference method [100 - (proteins + fats + moisture + ash in percentage)] (Muller & Tobin, 1980; Hussain *et al*., 2009). All the proximate values were reported in percentage.

Statistical analysis: Each experiment was repeated three times. The results are presented with their means, standard deviation and standard error using Microsoft Office Excel 2007.

Elemental analysis: Accurately weighed sample (3 g) in a crucible was subjected to ashing in furnace for 4 hour at 550 ºC. After cooling in desiccator, 2.5 mL of 6N HNO_3 was added to the crucible. The solution was filtered and diluted upto 100 mL with distilled water. The solution was analyzed for Ca, Mg, Na, K, P, Fe, Cu, Zn, Ni, Mn, and Se by using Atomic Absorption Spectrophotometer (AAS-Perkin Elmer, Model analyst 800). The results were obtained while using a working standard of 1000 ppm for each of the species (Khan & Hidayat, 2008; Hussain *et al*., 2010; Hussain *et al*., 2009).

Results and Discussion

Nutritional composition: Nutritional analysis of vegetables except moisture (wet and dry basis) was carried out on dry basis and has been reported in the Table 2. The moisture content of vegetables on wet basis was found to be highest for *C. moschata* (92.8%), while *A. sativum* showed a low value of only 62.9%. Similarly moisture content on dry basis was found to be highest in *S. melongena* (7.7%), and *M. charantia* showed a low value of only 5.418 % (Table 2). Ash value turned out to be high in *P. oleracea* (23.2%), and low in *A. sativum* (3.1%) (Table 2). Ash content determined in *P. oleracea* was found highest than reported by Srivastava (5.3%) (Srivastava *et al.,* 2006). Lockett had also reported high ash content in some greens used by the lactating mother such as bitter leaves, *Veronia colorata* (15.9%) and *Moringa oleifera* (15.1%) (Lockeett *et al*., 2000). This indicates *P. oleracea* could be good sources of mineral elements.

Table 2. Proximate analysis of selected vegetables of Mardan.

Species name	Moisture (W) (%) ± S.E	Moisture (D) (%) ± S.E	Ash (%) ± S.E	Fats (%) ± S.E	Fibers (%) ± S.E	Proteins (%) ± S.E	Carbohydrates (%) ± S.E	Energy value (kcal/100 g) ± S.E
A. esculentus	86.9 ± 0.1	7.4 ± 0.0	9.5 ± 0.0	5.0 ± 0.0	22.5 ± 0.0	7.8 ± 0.0	70.3 ± 0.1	357.689 ± 0.30
S. melongena	88.4 ± 0.1	7.7 ± 0.0	8.9 ± 0.0	5.2 ± 0.0	18.6 ± 0.0	9.7 ± 0.0	68.5 ± 0.1	359.535 ± 0.20
C. moschata	92.8 ± 0.1	5.8 ± 0.0	10.4 ± 0.0	6.1 ± 0.0	21.1 ± 0.0	14.3 ± 0.1	63.4 ± 0.1	365.857 ± 0.10
A. sativum	62.9 ± 0.1	6.8 ± 0.0	3.1 ± 0.0	0.3 ± 0.0	16.1 ± 0.1	9.5 ± 0.0	80.2 ± 0.1	361.659 ± 0.10
M. charantia	89.8 ± 0.1	5.4 ± 0.0	9.4 ± 0.1	8.3 ± 0.0	10.3 ± 0.0	16.9 ± 0.0	59.9 ± 0.0	382.646 ± 0.20
P. oleracea	87.4 ± 0.0	5.5 ± 0.0	23.2 ± 0.0	4.2 ± 0.0	17.7 ± 0.0	15.9 ± 0.0	51.3 ± 0.0	305.95 ± 0.080

The values with ± refers to SE. SE is the Standard Error, W = On wet basis, D = On dry basis

The fat contents of *M. charantia* (8.3%) were found to be much higher than *A. sativum* (0.3%). Al-Shahib & Marshal (2003) determined 0.2-0.5% lipids in various date palm varieties of *Phoenix dactylifera* (Gungor & Sengul, 2008). Similarly, Maisuthisakul *et al*., (2008) performed proximate analysis of some Thailand plants. According to his results, the fat content of *M. charantia* was about 1.7% which is significantly lower than that of our studied area plants. It is remarkable that the total amounts of fats determined in these vegetables are higher than most of the common vegetables (Table 2). Though, the vegetable species analyzed in this study are same, however, this difference in biochemical properties may be attributed to the ameliorated soil and climatic conditions of the area (García *et al*., 2002; Maisuthisakul *et al.,* 2008; Hussain *et al.,* 2009; Hussain *et al*., 2010). The protein contents determined for the vegetable samples were 7.8% for *A. esculentus,* 9.7% for *S. melongena,* 14.3% for *C.*

moschata, 9.5% for *A. sativum,* 16.9% for *M. charantia,* and 15.8% for *P. oleracea* (Table 2). The high crude protein contents of these vegetables may encourage their uses as high protein sources in some food formulations. It has been reported that protein-calories malnutrition deficiencies is a major factor responsible in nutritional pathology (Roger *et al.,* 2005). Plant food that provide more than 12.0% of its calorific value from protein are considered good source of protein (Pearson, 1976). The results of this work showed that adequate protein is present in these vegetables and are good diet for human beings. Crude fibers of these samples varied from 10.3 to 22.5% being lowest in *M. charantia* and highest in *A. esculentus* (Table 2). The American Dietetic Association (ADA) recommended an intake of 20-35 g of fiber per day (Duyff, 2002). As a nutritive value of food, fibers in the diet are necessary for digestion and for effective elimination of wastes (Vadivel & Janardhanan, 2005).

The carbohydrate contents of *A. sativum* (80.3%) determined was higher than *P. oleracea* (51.3%) which is lowest value among all the species as shown in (Table 2). Srivastava *et al*., (2006) reported 13.4% carbohydrate contents in *Momordica alba*, significantly lower than the amount determined in the present study. Looking at the results obtained from energy value, *M. charantia* (382.646 Kcal/100g) had highest and significant level of energy values as compared to the other species (Table 2).

Elemental composition: Elemental composition of the dry samples, reported on dry weight basis, is given in Tables 3 & 4. The vegetables were found to be good sources of Ca, Mg, P, Na, K, Ni, Cu, and Mn. These vegetables considered as sole source of macro and micro elements and can be used as one of the potential sources of the elements in the diet.

Table 3. Composition of micro elements of the selected vegetable species (ppm).

Species	Micro elements (ppm)					
	Fe	Zn	Mn	Cu	Ni	Se
A. esculentus	6.24	2	0.6	0.9	0.7	BD[a]
S. melongena	12.54	1.6	2.5	1.02	BD	BD
C. moschata	8	3.2	13	51	BD	BD
A. sativum	17	11.7	16.7	70	0.021	0.142
M. charantia	24.02	7.7	11	30.8	BD	BD
P. oleracea	9.24	0.242	2.2	0.121	0.082	BD

[a]BD = Below detection

Table 4. Composition of macro elements of the selected vegetable species (ppm).

Species	Macro elements (ppm)				
	Ca	Mg	K	Na	P
A. esculentus	750	571	2520	63	450
S. melongena	97	140	2400	75	250
C. moschata	210	120	3401	2	440
A. sativum	1815	250	4010	170	1532
M. charantia	90	160	3118	80	370
P. oleracea	144	94	2078	55	310

Among micronutrients, Fe (24 ppm) was found in greater amount in *M. charantia*, while *C. moschata* contained lesser amount (8 ppm) of Fe. The concentration of zinc in *A. esculentus, S. melongena, C. moschata, A. sativum, M. charantia* and *P. oleracea* was 2, 1.6, 3.2, 11.7, 7.7 and 0.242 ppm, respectively (Table 3). The positive impact of zinc supplementation on the growth of some stunted children, and on the prevalence of selected childhood diseases such as diarrhoea, suggests that zinc deficiency is likely to be a significant public health problem, especially in developing countries (Osendarp *et al*., 2003). According to FAO's food balance data, it has been calculated that about 20% of the world's population could be at risk of zinc deficiency. The average daily intake is less than 70 µg per day (Holt & Brown, 2004). The concentration of copper in *A. sativum* was found to be in greater amount (70 ppm), while lesser amount of copper was found in *P. oleracea* (0.24 ppm). Manganese contents of the vegetables were found as 0.6, 2.5, 13, 16.7, 11, and 2.2 ppm for *A. esculentus, S. melongena, C. moschata, A. sativum, M. charantia* and *P. oleracea* respectively (Table 3). The nickel concentration was found higher in *A. esculentus* (0.7 ppm) while other species has negligible concentration. The small quantity of selenium was found in *A. sativum* (0.142 ppm). Biologically, nickel also plays a key role in plants. As a matter of fact urease (an enzyme whish assist in the hydrolysis of urea) contains nickel. Other nickel containing enzymes include a class of superoxide dismutase (Sezilagyi *et al*., 2004). These nickel containing enzymes play integral role in human biological system.

Dairy products supply 50-80% of dietary calcium in most industrialized countries, while foods of plant origin supply about 25%. The calcium concentration in *A. sativum* was found the highest (1815 ppm) among all the vegetable species, while *A. esculentus* has 571 ppm concentration of Mg (Table 4). *A. sativum* is used chiefly by the local communities of the Mardan. However *A. esculentus* is a commonly used as a vegetable collected by the local people. In case of potasium, *A. sativum* has the highest concentration of 4010 ppm followed by *C. moschata*, which has a concentration of 3401 ppm. *A. sativum* was found to be in greater amount in phosphorus (1532 ppm), and sodium (170 ppm) among all the species (Table 4).

In comparative assessment of the various species, the results showed that *M. charantia* and *A. sativum* are most significant species having higher concentrations of fats, proteins, carbohydrates and energy value as compared to the other species (Table 2).

The correlation analysis of the selected parameters showed that similar parameter has highly significant correlation while among other parameters the correlation is either non-significant or less significant or moderate relation. Fat and protein, moisture (on wet basis) and fat, ash and protein, carbohydrate and energy value showing positive or significant correlation and similar pattern for other parameter as well. However, ash and carbohydrate, moisture (on wet basis) and protein, fat and carbohydrate have shown negative or non significant correlation (Table 5).

Table 5. Correlation matrix of nutritional parameters.

	Moisture (W)	Moisture (D)	Ash	Fat	Fiber	Protein	Carbohydrate	Energy value
Moisture (W)	1							
Moisture (D)	-0.2	1						
Ash	0.4	-0.4	1					
Fats	0.8	-0.3	0.2	1				
Fibers	0.1	0.4	0.09	-0.2	1			
Proteins	0.4	-0.9	0.5	0.5	-0.5	1		
Carbohydrates	-0.7	0.6	-0.8	-0.5	0.1	-0.8	1	
Energy values	-0.01	0.1	-0.8	0.3	-0.2	-0.1	0.5	1

- Shows negative correlation, W = Wet basis, D = Dry basis

Conclusion

The results indicated that all these vegetables have the potential to provide essential nutrients to the human beings. *M. charantia A. esculentus* and *A. sativum* were envisaged as a good source of fibers, fats, carbohydrates and energy values, hence capable of providing energy to the consumer. These vegetable species were also found significantly useful in terms of elemental resources; particularly Ni, K, P, Zn, Cu, and Mn levels, hence, elemental toxicity in the vegetables, lethal for the health is well below than WHO standards.

Acknowledgment

The authors wish to thank the Higher Education Commission, Government of Pakistan for providing financial support for the current study under the National Research Program for Universities (NRPU).

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(Received for publication 11 January 2011)