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# Nutritional Assessment and Mineral Composition of Some Selected Edible Vegetables

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Authors NUR, LA and FM performed the laboratory work and wrote the manuscript. Authors JH and AAl-H designed the study and revised the manuscript. Authors ALK and SAG performed the statistical analysis, and also carried out the Cluster and Principal Component Analyses. All authors read and approved the final manuscript.*

***Original Research Article***

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## ABSTRACT

**Aims:** The present study aimed to assess the nutritional significance of some of the commonly consumed vegetables collected from Hangu, Khyber Pakhtunkhwa, Pakistan.
**Study Design:** The study was designed in randomized block design and each analysis was performed with three replicates.
**Place and Duration of Study:** Kohat University of Science & Technology, Kohat and the duration of the study was one year.
**Methodology:** Present study was conducted to determine the nutritional importance of the commonly consumed vegetable viz. *Amaranthus caudatus, Lathyrus aphaca, Abelmoschus esculenthus, Solanum melongena*, *Raphanus sativus* and *Brassica rapa*. These vegetable species were evaluated for their nutritional values and mineral composition. By the nutritional analysis of these vegetable species, the total proteins, fats, carbohydrates, ash, and moisture contents were evaluated, whereas the macro-elements (Mg and Na) and micro-elements (Fe, Cu, Pb, Mn, Cr, and Cd) were analyzed using Atomic Absorption Spectrophotometric method.

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**Results:** The moisture content was found to be highest in *R. sativus* (13.59%±0.01), whereas *A. caudatus* was found to be highest in crude fats (2.91%±0.01), ash content (24.16% ± 0.03) and the protein value (15.65% ± 0.02). The fiber analysis indicated the highest value in *A. esculenthus* (30.93%±0.03), whereas *B. rapa* was found to be highest in the content of carbohydrates (86.65%±0.02) and thus the energy value was also calculated to be highest in *B. rapa* (352.52 ± 0.09). *A. caudatus* was also separated from the rest of the vegetables based on principal component analysis. 3-D component plot and rotated component matrix showed that this separation was due to variations in Pb and protein contents.

**Conclusion:** The results of this study revealed that *Amaranthus caudatus* and *Raphanus sativus* are the most balanced sources with respect to nutritional values and mineral composition, as both of them were found to contain the highest content of essential nutrients and the mineral elements (macro and micro-elements).

*Keywords: Nutritional composition; atomic absorption spectrophotometer; kjeldahl; mineral analysis.*

## 1. INTRODUCTION

The increasing populations of the world food demands have overwhelmed the available land resources. According to the FAO, there are about 840 million undernourished people in 1998–2000, of which 799 million are in the developing countries, 30 million in the countries in transition and 11 million in the industrialized countries [1]. Vegetables are very rich sources of essential bio-chemicals and nutrients such as carbohydrates, proteins, vitamins, calcium, iron and palpable concentration of trace minerals [2,3]. As among the other alternatives, vegetables are one of the cheap sources of energy and form the major portion of human diet due to presence of enough carbohydrates, fats, proteins, and other bio-chemicals. Proximate and nutrient analysis of edible fruit and vegetables plays a crucial role in the assessment of the nutritional significance.

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 [4]. 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 [5]. Nutrient analysis of edible fruits and vegetables plays a crucial role in assessing their nutritional significance [6,7].

*Amaranthus caudatus* belongs to the family Amaranthaceae. Amaranthaceae family consist of hardly, weedy herbaceous, fast growing, cereal like plants [8]. *Amaranthus caudatus* is used as anti-diarrheal, antihemorrhagic, astringent, emmenogogue, nutritive, tonic, galactogogue, diuretic. It is also used as anthelminthic and the leaves are rich in vitamins and minerals [9]. It is also used as vegetable for enriching iron deficiency [10,11]. Among these vegetables, *Solanum melongena* (Solanaceae) 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 [12]. Other medicinal values are anti-haemorrhoidal, hypotensive and narcotic [13].

*Brassica rapa* is a member of the cruciferous family of vegetables. It is commonly known as field mustard or turnip mustard, widely cultivated as a leaf vegetable, a root vegetable, and an oil seed. The leaves and stems are used in the treatment of cancer. The crushed ripe seeds of *Brassica rapa* are used as a poultice on burns, root when boiled with lard is used for breast tumors, salve derived from the flowers is said to help in skin cancer [14]. Moreover, extract is also useful for lowering uric acid and extracting renal stones. It increases visual keenness and is used to treat night blindness. The syrup strengthens the memory and root peelings contain a natural insecticide [15,16]. *Raphanus sativus* is an annual or biennial species of garden vegetable. It can vary in size, growing from 10 cm to 1.8 meters in height. It is considered to be an antiseptic, antirheumatic, appetite stimulant, diuretic, diaphoretic, irregular menstruation and rubefacient, an excellent source of vitamin C, and a powerful immune booster, stomach disorders and is also considered to be very effective in cases of sore throat and indigestion [17].

*Abelmoschus esculentus* also known as lady's finger, is a flowering vegetable in the mallow family. Even though, the plant is cultivated in tropical and warm temperate region around the world but the species is still poorly studied [18]. Medicinally, it is used in the treatment of catarrhal infections, gonorrhea, antispasmodic, diuretic, demulcent, cordial and stimulant, antioxidant, anticancer, promote cardiovascular & gastrointestinal health, and reduce acid reflux [19]. A member of the Leguminosae family, *Lathyrus aphaca* L belongs to the genus *Lathyrus* consisting of 187 species [20], widely cultivated as a food crop [21]. Traditionally it is used as a famine food [22].

On the basis of medicinal importance and considerable use of *Amaranthus caudatus, Lathyrus aphaca, Abelmoschus esculenthus, Solanum melongena*, *Raphanus sativus* and *Brassica rapa* in their diet motivated us to carry out the present proximate and nutrient analysis. In the course of nutritional assessment and mineral composition studies of medicinal plants [23-26], six vegetable species were subjected to proximate and elemental analysis. In proximate analysis ash, carbohydrate, proteins, fats, fibers, moisture and energy values were analyzed while in elemental analysis Mg, Na, Fe, Cu, Pb, Mn, Cr and Cd were estimated quantitatively. The details of the family, parts used and status of these vegetable species are summarized in Table 1.

**Table 1. Vegetables collected for the study**

| Botanical name | Family name | Parts used | Status |
|---|---|---|---|
| *A. caudatus* | Amaranthaceae | Leaves | Cultivated |
| *L. aphaca* | Fabaceae | Seeds | Cultivated |
| *A. esculentus* | Malvaceae | Legumes | Cultivated |
| *S. melongena* | Solanaceae | Fruits | Cultivated |
| *R. sativus* | Brassicaceae | Roots & Leaves | Cultivated |
| *B. rapa* | Brassicaceae | Roots & Leaves | Cultivated |

## 2. MATERIALS AND METHODS

### 2.1 Plants Collection and Identification

The selected vegetable species (*A. caudatus, L. aphaca, A. esculenthus, S. melongena*, *R. sativus* and *B. rapa*) were collected from various areas of Hangu region, packed in the kraft papers and herbarium sheets were prepared. These plants were identified and classified by the plant taxonomist, Mr. Shoab khan, at the Botany Department, Kohat University of Science and Technology, Kohat, Pakistan.

### 2.2 Sample Preparation

The vegetable samples were washed under running water and blotted dry. The moisture content of the vegetable species (dry) was determined at 105 ºC. The dried matter obtained was ground to a fine powder and was stored at 5 ºC in the air-tight containers and further analyses were performed according to the standard procedures reported in literature [25,26].

### 2.3 Methods Used for Nutritional Analysis

The nutritional analysis of all the samples included the evaluation of moisture content, ash, crude fibers, crude fats, proteins and carbohydrates. The moisture content was determined using oven dry method [27]. The ash was calculated by drying the samples in a furnace for 3 h at 550 ºC. Protein values of the samples were determined by micro Kjeldahl method [28], which involved the digestion of the samples to extract nitrogen in the form of ammonia or ammonium sulphate, followed by distillation and trapping of this nitrogen. Finally the titration of the trapped nitrogen against the known standard is carried out to determine quantitatively the amount of nitrogen. The nitrogen value was then converted to protein by multiplying with a factor of 6.25. Carbohydrates were determined by difference method. All the experiments were recorded in triplicates and the proximate values are reported in percentages [23-26,29].

### 2.4 Method Used for Mineral Analysis

The macro and micro-elements (Mg, Na, Fe, Cu, Pb, Mn, Cr, and Cd) of the vegetable species were analyzed using the Atomic Absorption Spectrometer (Perkin Elmer AA Analyst 700). The results were obtained using working standards of Perkin Elmer (1000 ppm) for each of the species [23-26].

### 2.5 Statistical Analysis

Each experiment was run in triplicates. The results were calculated for three independent determinations with their means, standard deviations and correlation matrix. Statistical analysis was performed using ANOVA Statistical Analysis System (SAS 9.1) using the reported procedure [30]. Principal component analysis was used as an extraction method while Promax with Kaiser Normalization was applied as orthogonal rotation. Hierarchical cluster analyses of vegetables using average linkage between groups. 3D component plot of nutritional and proximate data of vegetables species was used to look the interaction of various parameters. These analyses were carried out on SPSS (ver 16.0; SPSS USA). Duncan's multiple range tests (DMRT) was adopted by using Statistic Analysis System (SAS 9.1, USA) ($P$< 0.05).

## 3. RESULTS AND DISCUSSION

### 3.1 Proximate Analysis

*A. caudatus, L. aphaca, A. esculenthus, S. melongena*, *R. sativus* and *B. rapa* are the common vegetables which are being cooked in various combinations and are used as a part of food by the local communities of the Hangu region of Pakistan. Besides their usage as food item, these vegetable species are also exploited for their medicinal properties. Most of these species are utilized against various diseases by the local communities through their indigenous knowledge. Vegetables are a vital component of human diet that are eaten all year round [26] and taking into account this importance in the human diet; some selected vegetables from Pakistan are analyzed for their nutritional values.

The results of the nutritional analysis of the vegetable species with their standard deviation are summarized in Table 2 and the graphical representation of the comparative studies of the selected vegetables is given in Fig. 1. The moisture content was found to be highest in *R. sativus* (13.59% ± 0.01), whereas *A. caudatus* was found to be highest in crude fats (2.91% ± 0.01), ash content (24.16% ± 0.03) and the protein value (15.65% ± 0.02). The fiber analysis indicated the highest value in *A. esculenthus* (30.93% ± 0.03), whereas *B. rapa* was found to be highest in the content of carbohydrates (86.65% ± 0.02) and thus the energy value was also calculated to be highest in *B. rapa* (352.52 ± 0.09). The results of the analysis of macro and micro-elements are summarized in Table 3.

The results of the fat analysis indicated that *A. caudatus* (2.91% ± 0.01) and *S. melongena* (2.41% ± 0.02) have higher concentration of crude fats as compared to the other species in the study (Table 2). The fat content of the selected vegetables is low compared to the reported values (8.3-27.0%) in some vegetables consumed in West Africa [31,32]. The crude fat analysis showed that the selected species are deficient in fats and this makes them good for health. It was found in the results obtained from the fiber analysis that *A. esculenthus* (30.93% ± 0.03) contains the highest content of crude fiber followed by *S. melongena* (23.16% ± 0.02), and the other species were found to contain comparatively lower content of crude fiber (Table 2). As a nutritive value of food, fibers in the diet are necessary for digestion and for effective elimination of wastes, and can lower the serum cholesterol, the risk of coronary heart disease, hypertension, constipation, diabetes, colon and breast cancer [33, 34]. Thus *A. esculenthus* and *S. melongena* can be considered as a valuable source of dietary fiber in human nutrition during malnutrition.

In case of ash content (Table 2), it was found to be in the decreasing order of *A. caudatus* (24.16% ± 0.03), *L. aphaca* (8.49% ± 0.04) and *A. esculenthus* (8.43% ± 0.03) while *R. sativus* (0.79% ± 0.01) contain lesser amount of ash followed by *B. rapa* (0.63% ± 0.01). The ash content of *A. caudatus* was found high compared to the reported values (3.1 to 23.5%) of selected vegetables in Mardan [23] and (8.0 to 23.9%) of vegetable species in Karak [24] indicating that consumption of this specie might contribute higher mineral content. As the moisture content depends on the environmental conditions such as humidity, temperature, harvest time, and climate as well as storage conditions. Thus it is important for food scientists to be able to reliably measure moisture contents. Looking at the overall percentage of moisture composition, it was observed that it is highest in *R. sativus* (13.59% ± 0.01) followed by *S. melongena* (11.80% ± 0.05) and *A. caudatus* (11.72% ± 0.07), whereas the remaining species had comparatively lesser composition of moisture (Table 2). The low moisture content of the vegetables would hinder the growth of microorganisms and the storage life would be high [35]. The difference in moisture content between different plants is directly depended to the plant physiological setup and climatic changes.

**Table 2. Proximate analysis of the selected vegetables species**

| Vegetables | Moisture (%) | Ash (%) | Fats (%) | Fiber (%) | Protein (%) | Carbohydrates (%) | Energy Value (Kcal/100g) |
|---|---|---|---|---|---|---|---|
| *A. caudatus* | 11.72 ± 0.07b | 24.16 ± 0.03a | 2.91 ± 0.01a | 10.92 ± 0.02d | 15.65 ± 0.02a | 45.54 ± 0.06e | 270.97 ± 0.19c |
| *L. aphaca* | 7.66 ± 0.06d | 8.49 ± 0.04b | 0.56 ± 0.01c | 13.61 ± 0.02c | 8.95 ± 0.01c | 74.34 ± 0.01c | 338.18 ± 0.15b |
| *A. esculenthus* | 10.12 ± 0.05c | 8.43 ± 0.03b | 0.78 ± 0.01c | 30.93 ± 0.03a | 11.50 ± 0.01b | 69.16 ± 0.08d | 329.73 ± 0.17b |
| *S. melongena* | 11.80 ± 0.05b | 8.19 ± 0.04b | 2.41 ± 0.02b | 23.16 ± 0.02b | 10.23 ± 0.01b | 67.37 ± 0.09d | 332.10 ± 0.32b |
| *R. sativus* | 13.59 ± 0.01a | 0.79 ± 0.01c | 0.89 ± 0.01c | 0.67 ± 0.01e | 0.88 ± 0.01d | 83.84 ± 0.01b | 347.12 ± 0.11a |
| *B. rapa* | 11.51 ± 0.02b | 0.63 ± 0.01c | 0.22 ± 0.01c | 0.75 ± 0.01e | 1.98 ± 0.01d | 85.65 ± 0.02a | 352.52 ± 0.09a |

*For each set of treatment, the different letter indicates significant differences at $P < 0.05$ level by DMRT.*

**Table 3. Analysis of the micronutrients (Fe, Cu, Mn, Cr, Cd, and Pb) (ppm) macronutrients (Mg and Na) (ppm) and in the selected vegetables**

| Vegetables | Fe | Cu | Mn | Cr | Cd | Pb | Mg | Na |
|---|---|---|---|---|---|---|---|---|
| *A. esculenthus* | 5.01± 0.1c | 7.42± 0.1c | 0.28± 0.03c | 0.27± 0.01a | 0.13± 0.1b | 0.02± 0.01a | 23.62± 0.12a | 11.5± 0.93c |
| *L. aphaca* | 2.11± 0.3f | 0.03± 0.0 | 0.41± 0.01b | 0.58± 0.02a | 0.05± 0.03c | $BD_a$ | 21.2± 0.7a | 9.6± 0.83c |
| *A. caudatus* | 10.68± 0.2a | 8.02± 0.3b | 0.71± 0.02a | 0.15± 0.02a | 0.14± 0.02b | 0.18± 0.01a | 25.8± 0.8a | 53.6± 3.13b |
| *S. melongena* | 10.69± 0.4a | 9.32± 0.4a | 0.35± 0.08c | 1.1± 0.01a | 0.15± 0.03b | 0.24± 0.03a | 14.2± 0.9b | 10.7± 1.4a |
| *R. sativus* | 11.64± 0.7a | 8.85± 0.5b | 0.87± 0.02a | 0.5± 0.03a | 0.48± 0.09a | 0.14± 0.03a | 17.0± 0.4b | 72.6± 1.3a |
| *B. rapa* | 9.12± 0.2b | 5.24± 0.5d | 0.74± 0.04a | 0.05± 0.0 | 0.21± 0.01b | 0.31± 0.03a | 13.2± 0.5b | 11.0± 0.1c |

[a]*Below detection*

*For each set of treatment, the different letter indicates significant differences at $P < 0.05$ level by DMRT.*

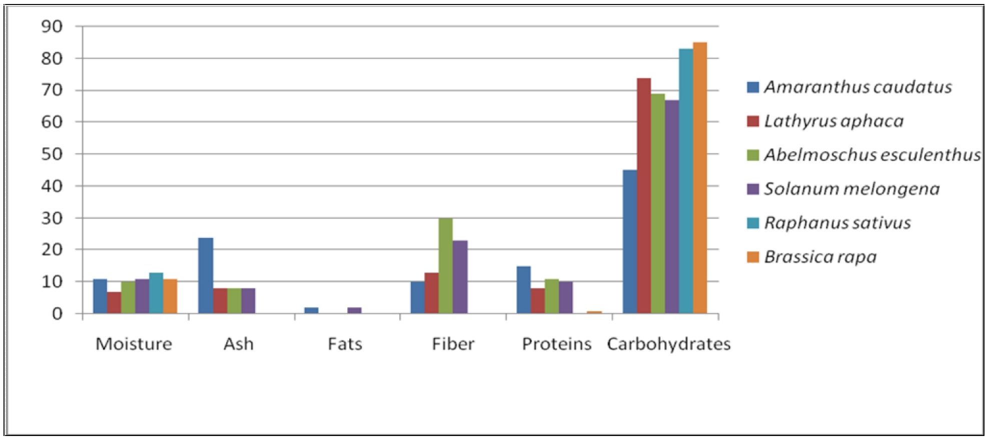


**Fig. 1. Graphical representation of the nutritional analysis (except energy value) of the selected vegetable species**

The analysis of the protein and carbohydrate contents in the selected six vegetable species showed that *A. caudatus* (15.65% ± 0.02) and *A. esculenthus* (11.50% ± 0.01) had highest concentration of protein as compared to the other species (Table 2), whereas *B. rapa* (85.65% ± 0.02) and *R. sativus* (83.84% ± 0.01) had the prominent levels of carbohydrate contents as compared to the other four species (Table 2). Plant food that provide more than 12.0% of its calorific value from protein are considered good source of protein [28]. The high protein content of *A. caudatus* 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 [36].

On the basis of the above mentioned parameters especially the proteins, carbohydrates and the fat contents, the energy value was calculated for the selected vegetable species in kcal/100g units and the following results were obtained; *B. rapa* (352.52 kcal/100g) and *R. sativus* (347.12 kcal/100g) had the highest and significant level of energy values being calculated per 100 gram of sample (Table 2), while the rest of the vegetable species had minor comparative energy values.

The graphical representation of these results is given in Fig. 1, which is useful to establish the inter species comparison and the inter parameter correlation. Looking at this graphical representation, it is evident that these vegetable species are the excellent sources of carbohydrates whereas the fat content is at minimum. However, the moderate content of fibers, proteins, moisture and ash is also present. Among each other, these species have shown comparative values of these parameters, and *B. rapa* has been considered as the best source of carbohydrates and energy, where as *A. esculenthus* have the highest fiber content, and *R. sativus* is rich in ash and have comparatively high content of protein and moisture. Thus it can be concluded that these vegetable species can be considered as the reasonable part of the diet as a whole and can be included in the daily diet. All these findings have been further confirmed through statistical correlation (Table 4).

### 3.2 Nutrients Analysis

The analysis of micro-elements of the vegetable species showed significant variations among different micro-elements (Table 3). In case of Cu, it was highest in *S. melongena* followed by *R. sativus* and *A. caudatus*. The considerable amount of Fe was found to be present in *R. sativus*, whereas the level of Mn was highest in *R. sativus*, and the highest Cd concentration was observed in *R. sativus* (Table 3). The remaining nutrients (Pb and Cr) had the negligible concentration levels (Table 3).

The range of Cr varies from 0.054 ppm in *B. rapa* to 1.102 ppm in *S. melongena*. It has been reported in literature [31] that Cr is toxic for many plant species at 5 mg/L concentration level or above. Cr plays an important role in the synthesis of fatty acids and cholesterols [37]. Chronic exposure to Cr may result in liver, kidney and lung damage [38]. Regarding Cr concentration, it can be concluded that all the studied vegetables have minor concentration of Cr as compared to the reported level for toxicity in plants [39]. In the studied vegetables, Cd concentration ranged from 0.057 ppm in *L. aphaca* to 0.485 ppm in *R. sativus.* Cd causes both acute and chronic poisoning, adverse effect on kidney, liver, vascular and immune system [40].

Among the investigated vegetables, *B. rapa* exhibits higher concentration of 0.312 ppm while *A. esculenthus* contains minimum amount of 0.021 ppm, which is far below the suggested acceptable concentration in plant species (2 to 6 mg/L). Pb poisoning is serious at any age, but children are relatively more vulnerable [41]. Pb toxicity causes anemia due to inhibition of heam biosynthesis and affects multiple body systems [42-44]. Thus the mineral analysis coupled with the analysis discussed already for the biochemicals further clarify the use of these vegetables as a food supplement. The above results were also explained on the basis of the graphical representation (Fig. 2), which indicated that the toxic nutrients (Cr and Pb) are present in negligible concentration which is even much lower than the accepted values; whereas the essential nutrients (Fe, and Cu etc.) are present in favorable concentration.

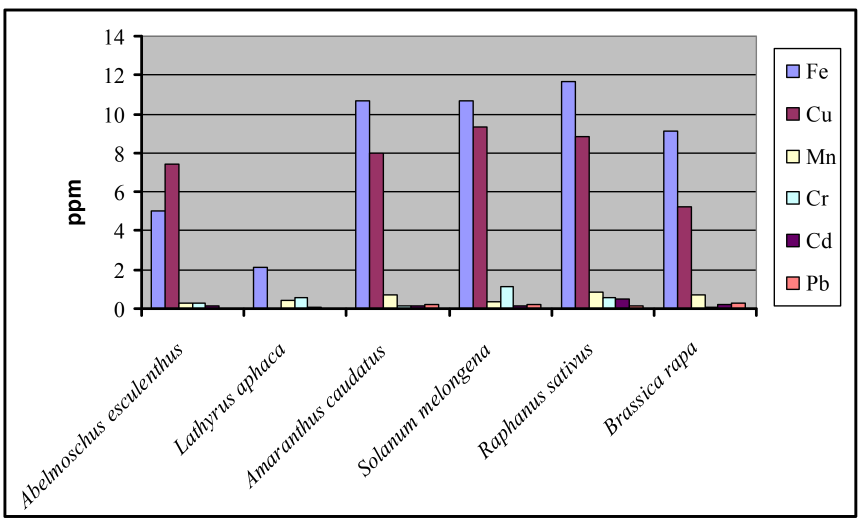


**Fig. 2. Graphical representations of the micronutrients of the selected vegetables**

The lowest concentration of Cu that is 0.031 ppm (*L. aphaca*) and maximum concentration was estimated at 9.32 ppm (*S. melongena*). The permissible limit set by FAO/WHO (1984) in edible plants was 3.00 ppm [45]. After comparison Cu limit in the studied vegetables, it is found that all vegetables accumulate considerable concentration of Cu except *L. aphaca*. It has been reported that Cu consumption in excess of 3.0 mg/L of drinking water result in nausea and other adverse effects on the gastrointestinal tract (GIT) [46].

The range of Fe in the studied vegetables varies from 2.119 ppm to 11.642 ppm. Fe is an essential trace element for haemoglobin formation, normal functioning of the central nervous system and in the oxidation of carbohydrates, proteins and fats [47]. The range of Mn varied with values between 0.287 ppm in *A. esculenthus* to 0.875 ppm in *R. sativus.* From the obtained results, it is found that all the selected vegetables accumulate trace elements below the limit proposed [45].

It is also evident from this graphical representation that Fe and Cu are present in fairly considerable concentration in almost all of the vegetable species except *L. aphaca*.

Na and Mg are sometime included in the macronutrient or macro-elements as they are required in comparatively larger amount by the human body. Thus they are considered as the more important component of the diet. The Na content of the studied vegetables varied from 9.69 ppm (*L. aphaca*) to 72.66 ppm (*R. sativus*). Sodium plays an important role in the transport of metabolites and the enhancement of blood pressure while Mg content helps in maintaining osmotic equilibrium and enzyme catalyzed reactions [48]. The content of Mg ranged between 13.22 ppm in *B. rapa* and 25.88 ppm in *A. caudatus.* The deficiency of Mg is associated with abnormal irritability of muscle and convulsions and excess Mg with depression of the central nervous system [48]. The analysis of these macro-elements indicated that all the selected vegetable species are rich in these minerals, however, *R. sativus* and *A. caudatus* showed the exceptionally high concentration of Na (72.66 ppm and 53.63 ppm respectively).

The correlation analysis of the selected parameters showed that similar parameters have highly significant correlation while among other parameters the correlation is either significant, or non-significant, and in some cases moderate. Proteins with carbohydrates; ash with carbohydrates and energy value; and fats with carbohydrates and energy value showed non-significant correlation and similar pattern for other parameters as well. However, ash and carbohydrates has showed significant correlation with proteins and energy values respectively (Table 4).

**Table 4. Correlation matrix of the proximate parameters of the selected vegetables**

| | **Moisture** | **Ash** | **Fats** | **Fiber** | **Proteins** | **Carbohydrates** | **Energy Value** |
|---|---|---|---|---|---|---|---|
| Moisture | 1 | | | | | | |
| Ash | -0.149 | 1 | | | | | |
| Fats | 0.308 | 0.780 | 1 | | | | |
| Fiber | -0.409 | 0.298 | 0.250 | 1 | | | |
| Proteins | -0.359 | 0.903 | 0.694 | 0.669 | 1 | | |
| Carbohydrates | 0.068 | -0.983 | -0.851 | -0.401 | -0.928 | 1 | |
| Energy Value | -0.039 | -0.978 | -0.806 | -0.190 | -0.826 | 0.968 | 1 |

*(-) sign shows the negative correlation*

### 3.3 Cluster and Principal Component Analyses

Hierarchical cluster analysis using average linkage between groups showed that *A. caudatus* was clustered separately from the rest of the five vegetables. In a major cluster, *R. sativus* and *B. rapa* were sub-clustered together, while *A. esculentus, S. melongena*, and *L. aphaca* were clustered together (Fig. 3). Principal component analysis using rotated component matrix and its 3D component plot showed that variations in Pb and protein contents had a significant role in separating *A. caudatus* from the rest of the clusters, because these contents were separated from the rest of the nutrients and chemical compounds on first (PC1), second (PC2), and third (PC3) components (Fig. 4 & Table 5).

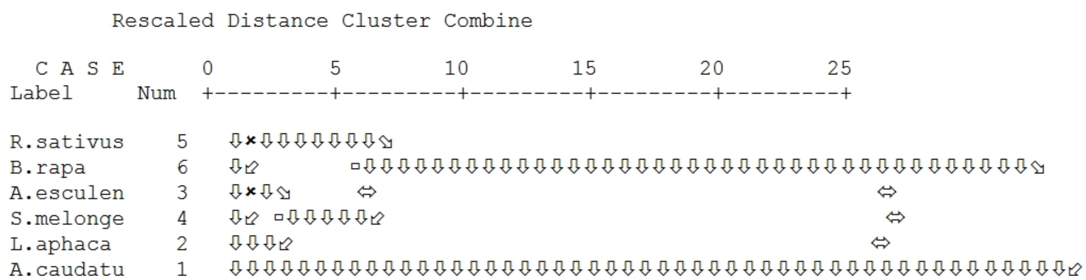


**Fig. 3. Hierarchical cluster analyses of vegetables using average linkage between groups**

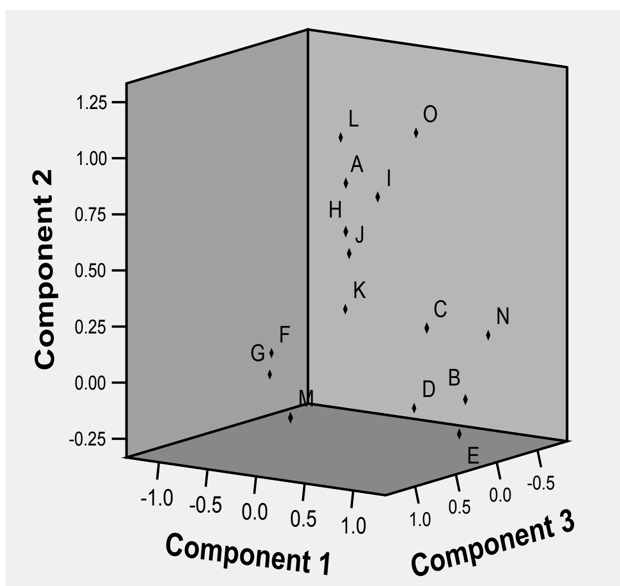


**Fig. 4. 3D component plot of nutritional and proximate data of five vegetables. A = moisture, B = ash, C = fats, D = fibers, E = proteins, F = carbohydrates, G = energy, H = Fe, I = Cu, J = Mn, K = Cr, L = Cd, M = Pb, N = Mg, and O = Na.**

**Table 5. Rotated component matrix[a] of nutrients and proximate data of five vegetables. Principal component analysis was used as an extraction method while Promax with Kaiser Normalization was applied as orthogonal rotation**

| Code | Nutrients | Principal Components | | | |
|---|---|---|---|---|---|
| | | PC1 | PC2 | PC3 | PC4 |
| A | Moisture | 0.657 | 0.699 | 0.185 | 0.106 |
| B | Ash | -0.766 | 0.598 | -0.175 | -0.123 |
| C | Fats | -0.417 | 0.815 | 0.328 | |
| D | Fibers | -0.726 | -0.166 | 0.523 | 0.276 |
| E | Proteins | -0.935 | 0.339 | | |
| F | Carbohydrates | 0.760 | -0.644 | | |
| G | Energy | 0.636 | -0.733 | 0.215 | 0.102 |
| H | Fe | 0.540 | 0.797 | 0.248 | |
| I | Cu | 0.249 | 0.732 | 0.460 | 0.226 |
| J | Mn | 0.695 | 0.465 | -0.525 | |
| K | Cr | | | 0.775 | 0.304 |
| L | Cd | 0.844 | 0.315 | | 0.425 |
| M | Pb | 0.530 | 0.420 | 0.262 | -0.687 |
| N | Mg | -0.756 | 0.256 | -0.493 | 0.332 |
| O | Na | 0.372 | 0.700 | -0.386 | 0.435 |

*[a]4 components extracted.*

## 4. CONCLUSION

To fulfill the nutritional needs of the local people various vegetable species are cultivated or collected from wild. The local people depend on these species for food and medicines. In the present study, six vegetable species were analyzed using the standard AOAC methods. Among these vegetable species, *A. caudatus* and *R. sativus* were proved to have high concentration of some macro and micro-elements while moderate level of nutrient parameters

## CONSENT

Not applicable.

## ETHICAL APPROVAL

Not applicable.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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