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# NUTRITIONAL QUALITY OF SOME CULTIVATED AND WILD SPECIES OF *AMARANTHUS* L.

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## ABSTRACT

Amaranthus vegetable and seeds are highly nutritious. Four species of *Amaranthus* were planted in pots in a glass house and leaves were harvested. Fresh leaves were analyzed for protein and carbohydrate content and oven dried leaves for Fe, Ca, K and Na contents. Protein content was varied from 6.10-9.00g/100g of fresh leaves. The amount of carbohydrate in fresh leaves of all four species varied from 9.75g-21.29g. Among the species, *A. spinosus* showed higher amount (21.29g) which is almost two folds higher than *A. tricolor* (9.75g). Results showed that *A. viridis* had higher accumulation (54mg). Overall K amount in the dry leaves of the four species varied between 2230-3900mg per 100 g of dry leaves and it was almost 2 fold differences between values of lowest and highest accumulation. The variation in amount of Ca was 38 fold higher, *A. spinosus* from the minimum amount (*A. blitum*). Fe content in dry leaves was maximum in *A. viridis* (15mg per 100g of dry wt) followed by *A. spinosus* (13.28mg), *A. tricolor* (10mg) and *A. blitum* (9mg). Wild species had more amount of Fe than cultivated species. The results of this study indicate a nutritive potential for the *Amaranthus* leaves, therefore, domestication of this plant is suggested along with assessment of its chemical and nutritional properties.

**INTRODUCTION:** Amaranth is an extremely interesting crop, which has been grown by the people of Central and Southern America until the 16th century. In the 1970's amaranth again attracted great attention as a food and fodder crop. Many investigators appreciated it as a valuable source of essential amino acids, whose deficit cannot be compensated by traditional agricultural crops.

In lysine content, amaranth exceeds 2 times that of wheat and three times that of maize. The nutritive value of amaranth proteins forms 75, compared with that of maize wheat and barley forming 44, 57 and 62 correspondingly. For comparison the nutritive value of cow milk forms 72 on the nutritionists' scale of protein quality [1].

The genus *Amaranthus* has received considerable attention in many countries because of the high nutritional value of some species that are important sources of food, either as vegetable or grain. The leaves contain 17.5 to 38.3% dry matter as protein of which 5% is lysine [2]. Vitamin A and C are also present in significant levels. Compared to spinach, *Amaranthus* contains three times more vitamin C, calcium and niacin.

Compared to lettuce, *Amaranthus* contains 18 times more vitamin A, 13 times more vitamin C, 20 times more calcium and 7 times more iron [3]. A study by Allemann *et al.* [4] showed that amaranth has the potential to be a valuable source of nutrition in areas in Africa with hot, dry climates. The crop can grow on marginal lands and when it gets well established it can

withstand acute drought conditions. The grain amaranth is a pseudo-cereal with unique nutritional and agronomic attributes. The amaranth seed containing starch, proteins, amino acids, lipids, minerals and vitamins has potential in the future for food and feed resources. There is a great deal of work on its chemical composition, protein and amino acid content, and nutritional value, including feeding tests [5-9].

With the above in mind, the main objective was to assess the nutrient content in the dry and fresh leaves of four *Amaranthus* species.

**MATERIALS AND METHODS:**

**Extraction and estimation of Proteins:** The total soluble protein contents in leaves of different amaranth species were extracted and assayed by using the method described by Lowry *et al*., [10]. 0.5g of leaves were washed in distilled water, and crushed and homogenized in 5ml of Tris-HCl buffer (pH 7.0) by using mortar and pestle. The homogenates were centrifuged at 5000 rpm for 20 minutes. Now 5ml of 10% trichloroacetic acid (TCA) was added to the supernatant and boiled in water bath for 3 minutes.

After cooling, the treated samples were centrifuged for 20 minutes at 5000rpm. The pellets were solubilized in 5ml of 0.1N NaOH. Subsequently, 5ml of alkaline reagent was added to the test tube containing 0.1ml of protein extract thoroughly mixed. The samples were allowed to cool for 10 minutes at room temperature and then 0.5ml of folin reagent was added to it. The reaction mixture was incubated for 30 minutes in temperature controlled water bath (37$^{o}$C).

After cooling, the intensity of the color developed (blue) was read at 650nm in a spectrocolorimeter (spectronic-20 Boasch & Lomb, USA). Protein estimation of each extract was performed in triplicate and the total soluble proteins in each sample was determined by using bovine serum albumin (Sigma) as standard and expressed in mg/gm fresh weight in case of leaves.

**Extraction and Estimation of total soluble Carbohydrates:** Total soluble carbohydrate was measured by the Anthrone method. 0.1g of fresh leaves was hydrolyzing by keeping it in a boiling water bath for three hours with 5ml of 2.5N HCl and then cools to room temperature. Neutralize it with sodium carbonate until the effervescence ceases. Make up the volume to 100ml and centrifuge and collect the supernatant. Carbohydrate estimation of each extract was performed in triplicate. Take 1ml aliquots for analysis. Add 4ml of ice-cold anthrone reagent, heat for 10 minutes in a boiling water bath. Cool rapidly in running tap water, read green to dark color at 630nm. The total soluble carbohydrate in each sample was determined by using glucose as standard and expressed in mg/100g fresh weight.

**Extraction procedure for Mineral Analysis:** After 15 days of growth period, seedlings were harvested and separated into roots and above ground parts and washed properly with distilled water. Shoot-leaves were dried in hot oven at 80$^{o}$C for 48 hours. 1g dry weight of tissues was wet digested in cylinders filled with $HNO_3$:$HClO_4$ (4:1 v/v) at 120-130$^{o}$C for five hours. After cooling, the volume of the sample was maintained upto 50ml with double distilled water and filtered by using Whatmann No 1 filter paper. The concentration of potassium, calcium, iron and sodium were analyzed by Atomic Absorption Spectrophotometer (Perkin-Elmer, Model 2380). Amount of elements were expressed as µg $g^{-1}$ DW.

**RESULTS:**

**Protein:** During investigation, the protein amounts in the fresh leaves of all four species of *Amaranthus* are shown in **Table 1a**. The results showed that *A. spinosus* had higher amount of protein (9g/100g) followed by *A. viridis* (7.85g), *A. blitum* (6.15g) and *A. tricolor* (6.10g). In comparison there was one and half fold difference between *A. viridis* and *A. tricolor*.

**Carbohydrate:** Similarly, the amount of carbohydrate in fresh leaves of all four species varied from 9.75g-21.29g (minimum to maximum). Among the species, *A. spinosus* showed higher amount (21.29g) which is almost two folds higher than *A. tricolor* (9.75g). After *A. spinosus* (wild), the cultivated species *A. blitum* had higher amount of carbohydrate (11.22g) followed by *A. viridis* (10.29g) (Table 1a). The results showed that in comparison wild species are richer in carbohydrate amount than cultivated species.

**TABLE 1a: PROTEIN AND CARBOHYDRATE CONTENTS IN THE LEAVES OF FOUR *AMARANTHUS* SPECIES (ON FRESH MASS BASIS mg/100g)**

| Species | Proteins | Carbohydrate |
|---|---|---|
| *A. spinosus* | 9.00±0.19 | 21.29±1.63 |
| *A. viridis* | 7.85±0.33 | 10.29±1.17 |
| *A. tricolor* | 6.10±0.26 | 9.75±1.24 |
| *A. blitum* | 6.15±0.46 | 11.22±0.95 |

## Mineral Analysis:

**Sodium (Na):** The Na content in the dry leaves of the four *Amaranthus* species are presented in Table 1b. Na content varied from species to species and that amount to 30mg-54mg per 100g of dry leaves. Results showed that *A. viridis* had higher accumulation (54mg) followed by *A. blitum* (39.38mg), *A. tricolor* (34mg) and *A. spinosus* as lowest amount (30mg). The results showed that Na was not equally uptake by species but capacity of Na absorption depended upon species response.

**Potassium (K):** Overall K amount in the dry leaves of the four species varied between 2230-3900mg per 100 g of dry leaves and it was almost 2 fold differences between values of lowest and highest accumulation. Surprisingly, accumulation was found negligible in case of *A. blitum*. *A. tricolor* had maximum amount of K (3900mg) followed by *A. spinosus* (2500mg) and *A. viridis* (2230mg) (**Table 1b**). The wild had highest capacity of accumulation.

**Calcium (Ca):** Ca amount in the dry leaves of the four *Amaranthus* species were investigated and presented in Table 1b. Overall results showed that there was large differences between minimum and maximum amount of accumulation which varied from 120mg-4500mg. *A. spinosus* had higher value (4500mg) followed by *A. tricolor* (2000mg), *A. viridis* (1995mg) and *A. blitum* (120mg). The variation in amount of Ca was 38 fold higher, *A. spinosus* from the minimum amount (*A. blitum*).

**Iron (Fe):** Fe content in dry leaves was maximum in *A. viridis* (15mg per 100g of dry wt) followed by *A. spinosus* (13.28mg), *A. tricolor* (10mg) and *A. blitum* (9mg). Wild species had more amount of Fe than cultivated species (Table 1b).

The accumulation of all the minerals as mentioned above was significantly different among the species. In case of most mineral content *A. spinosus* was above than rest of three and fewer amounts always persists in case of *A. blitum*. The results conclude the species of the plant can affect the uptake of minerals by plants.

**TABLE 1b: MINERAL CONTENTS OF THE LEAVES OF FOUR SPECIES OF *AMARANTHUS* (ON DRY MASS BASIS mg/100g)**

| Species | Na | K | Ca | Fe |
|---|---|---|---|---|
| *A. spinosus* | 30.00±1.52 | 2500±0.50 | 4500±0.93 | 13.28±0.81 |
| *A. viridis* | 54.00±7.70 | 2230±1.20 | 1995±0.48 | 15.00±0.62 |
| *A. tricolor* | 34.00±1.23 | 3900±1.01 | 2000±0.56 | 10.00±0.78 |
| *A. blitum* | 39.38±1.60 | negligible | 120.0±1.24 | 9.00±1.01 |

**DISCUSSION:** Leafy vegetables are the least expensive source of a number of protective nutrients and they are readily available throughout the year and grown in sufficient quantity in India. Earlier, Singh and Saxena [11] estimated cation in leafy vegetables at different stages of maturity and similarly Smith [12] has analyzed mineral content in 21 leafy vegetables.

Besides the above investigations, some important macromolecules were analyzed [13-14]. In the present study, contents of protein and carbohydrate from the fresh leaves of all four species have been analyzed. The amount of protein varies species to species and accommodated in the range of 6.10 to 9g/100g of leaves. The amount was higher in *A. spinosus* followed by decreasing trend in *A. viridis*, *A. blitum* and *A. tricolor* in the mature leaves. Similarly, carbohydrate content varies from 9.75-21.29 g/100g of fresh leaves, which showed great differences from lowest to highest value. *A. spinosus* showed maximum amount of carbohydrate and in *A. tricolor* minimum amount among all the species. The protein content values obtained in this study followed the same pattern of the amount of protein in seeds with significant marginal differences [15].

Amaranth leaves contain 17.5-38.3% dry matter as crude protein, averaging 5% lysine and thus having potential as a protein supplement as reported from plants grown in Europe [2]. In my findings the amount of protein in members of *Amaranthus* differ and showed 12-18% dry matter as crude protein, which indicated the reason of variation in soil condition and environmental factors.

The mineral contents in leaves of four species are represented in Table 1b. It was observed that *A. viridis* contains maximum amount of Na (54mg/g DW), followed by *A. blitum*, *A. tricolor* and *A. spinosus* . K was higher in *A. tricolor* followed by *A. spinosus,* and *A. tricolor*. Ca was higher in *A. spinosus* followed by *A. viridis, A. blitum* and *A. tricolor*. *A. spinosus* contains maximum amount of Fe followed by *A. viridis, A. blitum* and *A. tricolor*.

Generally, the leaves of all four species had low amount of Na and Fe and high in K and Ca. Earlier, Mnkeni *et al.* [16] reported low sodium content in seeds and with high potassium was high. Values of iron content obtained in this study were within the range of 12.23-14.55mg as reported in other *Amaranthus* species.

Content of Ca was almost similar in *A. viridis* and *A. tricolor* as reported by Escudero *et al.* [17] for *A. muricatus* (1533mg). This content was triple the value reported by Sanchez Marroquin [18] for *A. hypochond riacus* (360.4-375.3mg).

In this reported study, sodium contents were almost 4-5 times higher, in all species (30-54mg), in comparison to the earlier reports by Akubugwo *et al*. [19] for A. hybridus (7.48mg). Iron contents were almost similar (9-15mg). In comparison to other members in my study most of the members has low amount of iron and this may be supported with findings of Reddy and Kulkarni [20] very low availability of Fe were reported from 14 locally available and commonly consumed green leafy vegetables.

This was evidenced in-vitro that the large amounts of oxalates in the green leafy vegetables may be responsible for the low availability of Fe. Potassium and calcium contents were higher than the values reported by Akubugwo *et al*. [20].

Sodium and potassium are important intra and extra cellular cations. The Na/K ratio is important in determining the health status of an individual. Ca is important in bone and teeth. Fe is an essential trace element for haemoglobin formation, normal functioning of the central nervous system and energy metabolism [21-22].

These results suggested that wild species contain more amount of protein, carbohydrate, Na, K, Ca and Fe, than the cultivated species and amaranths are very good source of proteins, carbohydrate, Na, K, Ca and Fe. It is difficult to classify the amaranth into just one of the three main groups of plant foods normally recognized by nutrition specialists.

1. Cereals and tubers rich in carbohydrates.
2. Legumes and other source of plant protein.
3. Fruit and vegetables rich in iron and vitamins especially A and C.

Infact, amaranths belong to all three since, in addition to their leaves being used as a vegetable, the chief interest in their cultivation and use lies in their seeds which, as well as carbohydrates, contain between 6-9% proteins, with a high lysine content. At the maturation stage of plant, generally indicate the last deposited of mineral after expending at the different growth stage. It was observed that *A. spinosus* (wild) species store highest amount of minerals in comparison to cultivated ones. On the basis of above findings, it can argued that differences between mineral contents among the four species do not necessarily indicate that variety with higher amount of some minerals has a more efficient mechanism for absorption.

It simply means that species has more branch root system and may explore its soil efficiently [23-24]. On the other, difference in mineral storage also may be due to genetically controlled mechanisms of mineral nutrition in terms of absorption and translocation of particular elements [25]. The findings also support the earlier report about wide variation and low availability of Fe, where wide variation in total iron content in leaf vegetables has been reported [26].

The Fe contents obtained in this study in leaves were higher (15mg/100g) recorded in *A. spinosus*. This indicates that plant parts especially the leaves provide a good source of dietary, which provide energy and helps in enhancement of haemoglobin counts. Overall results may concluded with remark that *A. spinosus* was best suited for vegetable consumption since it has highest amount of minerals, protein and carbohydrate in leaves, which could be helpful for improving the quality of rural diets.

It gives a strong indication that area of the people where low haemoglobin or blood level, may perhaps be special interest in view of the importance for human diet (Decker *et al.* 2000). Since all the plant parts are good edible portion of the plant, the leaves could be richer in nutritional values especially in wild species in comparison to other angiospermic plants.

Further research is now necessary to create awareness of nutritional value of *Amaranthus* in rural areas and to include it in their gardens. In addition, training on how to utilize the grain and vegetable is also necessary.

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