Nutraceutical Assessment of Four Amaranthus Species from Burkina Faso

Ouedraogo Ibrahim¹, ²Hilou Adama, ¹Sombie Pierre Alexandre Eric Djifaby,
³Compaaou Moussa, ²Millogo Jeanne and ¹Nacoulma Odile Germaine
¹Laboratoire de Biochimie et de Chimie Appliquées (LABIOCA),
²Laboratoire de Biologie et Ecologie Végétale, UFR-SVT, Université de Ouagadougou,
09 BP 848 Ouagadougou 09, Burkina Faso

Abstract: The use of the amaranths as vegetables is developed in Burkina Faso. Most known are Amaranthus dubius Mart. Ex. Thell, Amaranthus graecizans L., Amaranthus hybridus L. and Amaranthus viridis L. A. hybridus is most used and abundantly cultivated, however the others are more or less wild. The aim of the present study was to investigate the nutraceutical potentialities of four Amaranthus species from Burkina Faso. The aqueous decoction extract of the four species contains the highest of polyphenols, flavonoids, flavonols and proteins contents. The aqueous decoction extracts were used for the evaluation of the antioxidant activity and xanthine oxidase inhibitory potentiality. The A. dubius showed the most potent antioxidant activity with a CE50 of 1.26±0.46, mgm2 the $\beta$-carotene bleaching method. A. hybridus showed the most potent antioxidant activity (66.99±1.65 molAEAC/g) in the DPPH radical scavenging method. The aqueous extracts of the four species showed weak inhibition of the xanthine oxidase at the concentration of 200 $\mu$g/mL. The four Amaranthus species are rich in microelements (Na, K, Ca, Mg, P, Fe, Mn, Zn and Cu) and carotenoids compounds. The anti-nutritional factors were also quantified. The oxalate amount in these species is fairly high. The highest minerals contents and the antioxidant activity of the amaranths could explain their large use by all the socio-economic strata of the population. These plants would constitute a source of dietetic antioxidants.

Key words: Amaranthaceae, antioxidant activity, oxalate, phenolic and minerals content, xanthine oxidase

INTRODUCTION

The food supply of certain substances which finds in the plants, the animals and the minerals kinds are one of the major prerequisites to the maintain health. The natural substances resulting from the vegetable kingdom are traditionally sources of food, drugs for the man (Nacoulma, 1996).

Amaranthus plants (Amaranthaceae) are spread throughout the world, growing under a wide range of climatic conditions and they are known to infest or to produce useful feed and food products (Rastrelli et al., 1995). The leaves of amaranth constitute an inexpensive and rich source of protein, carotenoids, vitamin C and dietary fibre (Shukla et al., 2006), minerals like calcium, iron, zinc, magnesium (Kadoshnikov et al., 2008; Shukla et al., 2006), and phosphorus (Ozbucak et al., 2007). The use of these vegetables in traditional medicine was also reported (Nsirnba et al., 2008; Nacoulma, 1996).

The amaranths are cultivated like vegetables for their edible sheets with the manner of spinaches and sometimes like decorative plants for their spectacular ear flowering. Amaranthus dubius, Amaranthus graecizans, Amaranthus hybridus and Amaranthus viridis are mainly used like cooked vegetables, only or in association between them or with other plants like Hibiscus sabdariffa (Malvaceae).

Amaranthus dubius is recommended like food plant having medicinal properties for the young children, the nursing mothers, and for patients suffering from anaemia, kwashiorkor and insomnia (Nacoulma, 1996). In Tanzania, the whole plant is used as drug against the stomachache. Ethanolic extract of A. dubius showed a good inhibition of lipoxygenase (CE50 = 69.4 $\mu$g/mL) at the concentration of 100 $\mu$g/mL (Uma and Odhav, 2008).

Amaranthus graecizans is also used like fodder for the cattle. In Mauritania, one prepares fine wafers with seeds, whereas in the west of the United States one crushes them to make flour of it. In Uganda, the sheets are used to treat tonsilititis but in Senegal; the sheets are used as vermifuge (Maundu and Grubben, 2004).

In Burkina Faso, Amaranthus hybridus is used in the affections of liver, of the knee ache and the macerated aqueous is used as vermifuge (worm of Guinea). It is also used for its nematicides vertues, healing, diuretic and laxative in the children (Nacoulma, 1996). The aqueous
MATERIALS AND METHODS

Plant sample collection: The leaves of the four plants were harvested in Ouagadougou, capital of Burkina Faso in June 2009. The plants were identified by Prof. Millogo, botanist at the University of Ouagadougou.

Extract preparation: A crude distilled water extract was prepared by heating powdered plant (25 g) in a flask with 250 mL distilled water for 30 min whilst stirring. Similarly, 25 g of powdered plant was extracted successively with methanol in a Soxhlet apparatus for 24 h. The extracts were filtered and evaporated to dryness in a rotary evaporator. All the extracts were kept at 4°C and were dissolved in water or solvent before use.

Nutritional factors evaluation methods:
Protein content: The protein content was estimated by using the method of Lowry et al. (1951). 0.6 mL of plant extract (EM, DA) was mixed with 3 mL of the Lowry reagent (1 mg/mL). Mixture was incubated during 10 mins. It is then added 0.3 mL of the Folin-Ciocalteu reagent (1N). The mixture is also homogenized and incubated during 30 mins and the absorbance was measured at 660 nm. The protein content was determined using standard curves for Bovine Serum Albumin (50-500 μg/mL). The test is carried out in triplet for each extract. The protein concentration of the vegetable extract is expressed as mg equivalent BSA for 100 mg of extract.

Mineral analysis: The mineral elements comprising sodium, calcium, potassium, magnesium, iron, zinc and phosphor were determined according to the method of Shahidi et al. (1999) and Nahapetian and Bassir (1975) with some modifications. Two (2.0) g of each of the processed samples was weighed and subjected to dry ashing in a well-cleaned porcelain crucible at 550°C in a muffle furnace. The resultant ash was dissolved in 5.0 mL of HNO₃/HCl/H₂O (1/2/3) and heated gently on a hot plate until brown fumes disappeared. To the remaining material in each crucible, 5.0 mL of de-ionized water was added and heated until a colorless solution was obtained. The mineral solution in each crucible was transferred into a 100.0 mL volumetric flask by filtration through Whatman No. 42 filter paper and the volume was made to mark with de-ionized water. This solution was used for elemental analysis by atomic absorption spectrophotometer (AAS300, Perkin Elmer). A concentration of each element in the sample was calculated on percentage (%) of dry matter (mg/100 g sample). Phosphor content of the digest was determined colorimetrically according to the method described by Nahapetian and Bassir (1975).

β-Carotene and lycopene determination: β-Carotene and lycopene were determined according to the method of Nagata and Yamashita (1992). The dried extract (100 mg) was vigorously shaken with 10 mL of acetone-hexane mixture (4:6) for 1 min and filtered through Whatman No. 4 filter paper. The absorbance of the filtrate was measured at 453, 505 and 663 nm. Contents of β-carotene and lycopene were calculated according to the following equations:

\[-\text{Carotene (mg/100 mL) = -0.0458 A663} + 0.372 A505 - 0.0806 A453\]
\[-\text{Lycopene (mg/100 mL) = 0.216 A663} - 0.304 A505 + 0.452 A453\]

The assays were carried out in triplicate; the results were mean values ± standard deviations and expressed as mg of β-carotene/g and mg of lycopene/g of extract.
Functional activity assessment method:

Determination of the antioxidant activity with the b-carotene bleaching method: The antioxidant activity of the extracts was evaluated by the method of Mi-Yae et al. (2003) with some modification. A solution of β-carotene was prepared by dissolving 8 mg of β-carotene in 10 mL of chloroform. 0.5 mL of this solution was introduced into 100 mL round-bottom flask. Chloroform is removed under vacuum at 40°C. Forty seven (47) μL of linoleic acid, 362 μL of Tween 40 and 100 mL of distilled water were added. The mixture was shaken vigorously to form the emulsion. Aliquots (4.8 mL) of this emulsion are transferred in test tubes containing 0.2 mL of different concentrations of the extracts.

The tubes are shaken and incubated at 50°C for 2 h. The absorption at zero time is measured just after the addition of the emulsion then that at the end of the 2 h of incubation to 470 nm. The antioxidant activity was calculated by using the following equation:

\[
AA = \frac{[1 - (A_0 - A_t) / (A'_0 - A'_t)] \times 100}{\text{where, } A_0 \text{ and } A'_0 \text{ are the absorbance measured at zero time of incubation for the test sample and control, respectively, and } A_t \text{ and } A'_t \text{ are the absorbancemasured in the test sample and control, respectively, after incubation for 2 h.}}
\]

DPPH radical method: Ability of the extracts to scavenge the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical was evaluated as described by Lamien-Meda et al. (2008). Extracts were dissolved in methanol and 0.75 mL of each was mixed with 1.5 mL of a 0.02 mg/mL solution of DPPH in methanol. The mixtures were left for 15 min at room temperature and the absorbance was measured at 517 nm. The blank sample consisted of 0.75 mL of methanol (2 %). The absorbance was read at 415 nm after 10 min against a blank sample consisting of a methanol (2 %). The straight line equation is \( y = 0.0095x \), with \( R^2 = 0.9966 \). The results were expressed as mg of gallic acid equivalents (GAE)/100 mg of plant weight.

The total flavonoid content was estimated according to Almaraz-Abarca et al. (2007). In each tube, it is mixed 750 μL of extract (0.1 mg/mL) prepared in water and 750 μL of an aqueous solution of AlCl3 (20%). For each extract, the test is carried out in triple. A blank sample is carried out by the mixture of extract (750 μL) and ethanol (750 μL). The optical density is read after 10 min of incubation to the wavelength of 425 nm. Quercetin (0-50 mg/L) was used as reference compound to produce the standard curve, and the results were expressed as mg of quercetin equivalents (QE)/100 mg of plant weight. The straight line equation is \( y = 0.0249x \), with \( R^2 = 0.9943 \).

The total flavonol content was estimated according to the method of Almaraz-Abarca et al. (2007). In each tube, it is mixed 750 μL of extract (0.1 mg/mL) prepared in ethanol and 750 μL of an aqueous solution of AlCl3 (20%). For each extract, the test is carried out in triple. A blank sample is carried out by the mixture of extract (750 μL) and ethanol (750 μL). The optical density is read after 10 min of incubation to the wavelength of 425 nm. Quercetin (0-50 mg/L) was used as reference compound to produce the standard curve, and the results were expressed as mg of quercetin equivalents (QE)/100 mg of plant weight.

Xanthine oxidase inhibition: The inhibiting activity of the extracts on XO (EC.1.1.3.22) was evaluated according to the method described by Ferraz Filha et al. (2006) with light modifications. The percentage of inhibition is determined by kinetic measurement with 295 nm light modifications. The percentage of inhibition is calculated as follows:

\[
I(\%) = \frac{V_0 - V}{V_0} \times 100
\]

%: percentage of inhibition of the XO. Vo: variation of the absorption of the test without the plant extract. V: variation of the absorption of the test with the plant extract.

Phytochemistry assessment methods:

The total phenolic content: of each fruit extract were determined as described by Lamien-Meda et al. (2008). The diluted aqueous solution of each extract (0.5 mL) was mixed with FolinCiocaleu reagent (0.2 N, 2.5 mL). This mixture was allowed to stand at room temperature for 5 min and then sodium carbonate solution (75 g/L in water; 2 mL) was added. After 2 h of incubation, the absorbances were measured at 760 nm against water blank. A standard calibration curve was plotted using gallic acid (0-100 mg/L). The straight line equation is \( y = 0.0095x \), with \( R^2 = 0.9966 \). The results were expressed as mg of gallic acid equivalents (GAE)/100 g of plant weight.

The total flavonoid content was estimated according to Lamien-Meda et al. (2008). A diluted methanolic solution (2 mL) of each fruit extract was mixed with a solution (2 mL) of aluminiumtrichloride (AlCl3) in methanol (2 %). The absorbance was read at 415 nm after 10 min against a blank sample consisting of a methanol (2 mL) and plant extract (2 mL) without AlCl3. Quercetin (0-50 mg/L) was used as reference compound to produce the standard curve, and the results were expressed as mg of quercetin equivalents (QE)/100 g of plant weight. The straight line equation is \( y = 0.0249x \), with \( R^2 = 0.9943 \).

The total flavonol content was estimated according to the method of Almaraz-Abarca et al. (2007). In each tube, it is mixed 750 μL of extract (0.1 mg/mL) prepared in ethanol and 750 μL of an aqueous solution of AlCl3 (20%). For each extract, the test is carried out in triple. A blank sample is carried out by the mixture of extract (750 μL) and ethanol (750 μL). The optical density is read after 10 min of incubation to the wavelength of 425 nm. Quercetin (0-50 mg/L) was used as reference compound to produce the standard curve, and the results were expressed as mg of quercetin equivalents (QE)/100 mg of plant weight.

Anti-nutritionalevaluation methods:

Oxalate content determination: Briefly, the determination of Oxalate content was previously described by Oke (1966). Two (2) g of the sample was digested with 10 mL of hydroxylamine hydrochloride (HCl) at 100°C. The absorbance was read at 425 nm against a blank sample consisting of a methanol (2 mL) and plant extract (2 mL) without AlCl3. Quercetin (0-50 mg/L) was used as reference compound to produce the standard curve, and the results were expressed as mg of quercetin equivalents (QE)/100 mg of plant weight.
of HCl (6M) for one hour and made up to 250 mL in a volumetric flask. The pH of the filtrate was adjusted with NH₄OH (28%) until the color of solution changed from salmon pink color to a faint yellow color. Thereafter, the filtrate was treated with 10 mL of 5% CaCl₂ solution to precipitate the insoluble oxalate. The suspension is now centrifuged at 2500 rpm, after which the supernatant was decanted and precipitate completely dissolved in 10 mL of 20% (v/v) H₂SO₄. The total filtrate resulting from the dissolution in H₂SO₄ is made up to 300 mL. An aliquot of 125 mL of the filtrate was heated until near boiling point and then titrated against 0.05 M of standardized KMnO₄ solution to a faint pink color which persisted for about 30 s after which the burette reading was taken. The oxalate content was evaluated from the titer value. The overall redox reaction is:

\[ 2\text{MnO}_4^{2-} + 5\text{C}_2\text{O}_4^{2-} + 16\text{H}^+ \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 10\text{CO}_2 \]

**The total tannin content quantification:** The total tannin content was proportioned by using the reference method of European commission (2000). 200 µL of extract was mixed with 1 ml of distilled water, 200 µL of ferric ammonium citrate(3.5 g/L) prepared freshly and 200 µL of ammoniac (20%). The solution absorption is measured at 525 nm after 10 mnsof incubation against a blank (200 µL of extract + 1200 µL distilled water).

Tannic acid (0-150 mg/L) was used as reference compound to produce the standard curve, and the results were expressed as mg of tannic acid equivalent (TE)/100 mg of plant weight.

**Statistical analysis:** Results were expressed as the mean ±standard deviation of triplicate analysis. Statistical comparisons were performed using Analysis of Variance (ANOVA) of XLSTAT Pro. Differences were considered significant at p<0.05.

**RESULTS AND DISCUSSION**

**Extraction yields:** The various extractions gave the yields between 7.1 and 17.32. The yield of the aque decoction extract showed the most significant values: 17.32, 9.64, 15.4 and 13.08, respectively for *A. dubius, A. graecizans, A. hybridus* and *A. viridis*. This translated the richness of the four species in water soluble polar compounds. The aqueous decoction extract is particularly interesting because it corresponds to the method of traditional use.

**Nutritional factors:** The proteins, β-carotene and lycopene content of the four species are consigned 1. The contents of proteins in the various extracts are included between 24.42±4.17 and 51.56±3.37 mg BSA Equivalent/100 mg. The decoction allowed the best protein extractions. *A. hybridus* shows a more significant content of proteins with 56±3.37 mg BSA Equivalent/100 mg for the aqueous extract. The amount of *A. dubius* and *A. graecizans* are appreciably close as well in the Aquoeous Extract (AE) as in Methanolic Extract (ME).

A protein concentrate obtained from *A. hybridus* showed a content of protein of 35.1 mg/100 mg of matter (Aletor and Adeogun, 1995). Although the adopted method is different from ours, this result is comparable with those of ME of *A. hybridus* which is 37.89 mg BSA Equivalent for 100 mg of extract.

The contents of β-carotene are of 13.94±0.79, 5.72±0.42, 0.98±0.21, 3.05±0.53 mg/100 g of dry matter, respectively for *A. dubius, A. graecizans, A. hybridus* and *A. viridis*.

Studies carried out (Rajyalakshmi et al., 2001; Singh and Sehgal., 2001) reported that the leaves of amaranth contain between 2.3 and 14.7 mg of β-carotene /100 g of dry matter. The content of our plants is in the tendency indicated except for *A. hybridus* which contains less. The regular consumption of these amaranths thus takes part to avoid the deficiencies in vitamin A.

The food plants contribute to approximately more than 80% of source of dietetic vitamin A in the countries in the process of development (Bhaskarachary et al., 1995). The plants molecules, such as carotenoids, present effective antioxidant properties. A food rich in β-Carotene would make it possible to decrease the rate of vitamin A deficiency as well as the synthetic supplementation of vitamin A (Gopalan, 1992).

The lycopene contentare of 0.22±0.05, 4.28±0.98, 0.27±0.092, 0.15±0.06 mg/100 g of dry matter, respectively for *A. dubius, A. graecizans, A. hybridus* and *A. viridis*. The lycopene content of our four species in fresh matter varies between 0.25 and 7.27 mg/kg. These amountare very weak compared to other vegetables as the tomato (*Lycopersicon esculentum*) which is of 145.50 mg/kg fresh matter (Basuny et al., 2009).

**Mineral composition:** The content of minerals is higher at followed by *Amaranthus hybridus* and *Amaranthus viridis*. *Amaranthus dubius*, *Anthus graecizans* is lowest in minerals.

The magnesium amount of these species is comparable with those reported by Ladan et al. (1996), Antia et al. (2006) and Hassan and Umar (2006) in some green vegetables. It is a significant biogenic salt in connection with the cardiac ischemic diseases and the metabolism of calcium in bones (Ishida et al., 2000).

Iron is essential for the formation of hemoglobin, normal operation of the central nervous system and in the oxidation of the carbohydrates, proteins and greases (Adeloye and Otokili, 1999).

The zinc content (3.01 mg/100 g for *A. hybridus*) is comparable with the majority of the values reported for...
Table 1: Protein, β-carotene and lycopene content

<table>
<thead>
<tr>
<th>Species</th>
<th>A. dubius</th>
<th>A. graecizans</th>
<th>A. hybridus</th>
<th>A. viridis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein mgAE</td>
<td>32.44±2.93d</td>
<td>36.11±4.88c</td>
<td>51.55±3.37a</td>
<td>45.72±4.88e</td>
</tr>
<tr>
<td>BSAE/100mg of ExtractME</td>
<td>24.41±4.17b</td>
<td>23.86±2.93d</td>
<td>37.88±5.67a</td>
<td>13.97±1.73c</td>
</tr>
<tr>
<td>β-Carotene mg/100g Dries Matter</td>
<td>13.94±0.79a</td>
<td>5.72±0.42b</td>
<td>0.88±0.215c</td>
<td>0.27±0.099b</td>
</tr>
<tr>
<td>Lycopene mg/100g Dries Matter</td>
<td>0.22±0.05d</td>
<td>4.28±0.98b</td>
<td>0.27±0.099b</td>
<td>0.15±0.062</td>
</tr>
</tbody>
</table>

Data are mean±SEM (n = 3); AE: aqueous extract; ME: methanolic extract; Values showing the same letter are not significantly different (p<0.05) from one other in the same line.

Table 2: Contents of minerals mg/100g in dries matter

<table>
<thead>
<tr>
<th>Species</th>
<th>A. dubius</th>
<th>A. graecizans</th>
<th>A. hybridus</th>
<th>A. viridis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>15.32±0.11d</td>
<td>6.92±0.07</td>
<td>6.17±1.25c</td>
<td>27.2±0.08a</td>
</tr>
<tr>
<td>K</td>
<td>64.09±0.06e</td>
<td>5.02±0.08</td>
<td>5.20±2.60c</td>
<td>47.15±0.12e</td>
</tr>
<tr>
<td>Ca</td>
<td>55.71±0.01f</td>
<td>2.55±0.07</td>
<td>50.29±1.32c</td>
<td>37.86±0.10c</td>
</tr>
<tr>
<td>Mg</td>
<td>186.18±0.08g</td>
<td>2.64±0.08</td>
<td>209.10±2.79c</td>
<td>111.09±0.12c</td>
</tr>
<tr>
<td>P</td>
<td>53.81±0.12d</td>
<td>7.95±0.09</td>
<td>37.66±1.10c</td>
<td>23.11±2.11c</td>
</tr>
<tr>
<td>Fe</td>
<td>8.24±0.52c</td>
<td>0.21±0.04</td>
<td>11.25±0.09c</td>
<td>4.56±0.11f</td>
</tr>
<tr>
<td>Mn</td>
<td>1.31±0.09f</td>
<td>0.16±0.06</td>
<td>1.10±0.08f</td>
<td>0.41±0.09f</td>
</tr>
<tr>
<td>Zn</td>
<td>5.86±0.10f</td>
<td>0.25±0.01</td>
<td>3.01±0.74f</td>
<td>6.79±0.06f</td>
</tr>
<tr>
<td>Cu</td>
<td>11.67±0.16f</td>
<td>0.39±0.07</td>
<td>11.17±1.45f</td>
<td>9.10±0.01f</td>
</tr>
</tbody>
</table>

Data are mean±SEM (n = 3); Values showing the same letter are not significantly different (p<0.05) from one other in the same line.

Table 3: Antioxidant activity and inhibiting capacity of the xanthine oxidase

<table>
<thead>
<tr>
<th>Species</th>
<th>A. dubius</th>
<th>A. graecizans</th>
<th>A. hybridus</th>
<th>A. viridis</th>
</tr>
</thead>
<tbody>
<tr>
<td>α-Tocopherol (Control)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>DPPH (μmol AEAC/g extract)</td>
<td>0.49±0.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Quercetin</td>
<td>13760±0.26</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Data are mean±SEM (n = 3); Xo: xanthine oxidase inhibition; Values showing the same letter are not significantly different (p<0.05) from one other in the same line.

Table 4: Chemical composition

<table>
<thead>
<tr>
<th>Species</th>
<th>Extract</th>
<th>Phenolics mg GAE/100 mg of extract</th>
<th>Flavonoids mgQE/100 mg of extract</th>
<th>Flavonols mgQE/100 mg of extract</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. dubius</td>
<td>AE</td>
<td>10.00±0.18</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>ME</td>
<td>12.08±0.31</td>
<td>1.33±0.26</td>
<td>0.68±0.07</td>
</tr>
<tr>
<td>A. graecizans</td>
<td>AE</td>
<td>15.34±0.93</td>
<td>5.50±0.37</td>
<td>0.95±0.03</td>
</tr>
<tr>
<td></td>
<td>ME</td>
<td>12.37±0.47</td>
<td>1.50±0.10</td>
<td>66.99±1.65</td>
</tr>
<tr>
<td>A. hybridus</td>
<td>AE</td>
<td>22.42±0.3</td>
<td>12.73±1.61</td>
<td>33.67±2.06</td>
</tr>
<tr>
<td></td>
<td>ME</td>
<td>17.63±0.38</td>
<td>6.69±0.19</td>
<td>0.12±0.01</td>
</tr>
<tr>
<td>A. viridis</td>
<td>AE</td>
<td>8.46±0.17</td>
<td>6.93±0.22</td>
<td>0.42±0.03</td>
</tr>
<tr>
<td></td>
<td>ME</td>
<td>11.78±0.14</td>
<td>-</td>
<td>0.39±0.02</td>
</tr>
</tbody>
</table>

Data are mean±SEM (n = 3); AE: aqueous extract; ME: methanolic extract; Values showing the same letter are not significantly different (p<0.05) from one other in the same columns.

Table 5: Contents of tannin and oxalate

<table>
<thead>
<tr>
<th>Species</th>
<th>A. dubius</th>
<th>A. graecizans</th>
<th>A. hybridus</th>
<th>A. viridis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tannins AE 100 mg of extract</td>
<td>1.74±0.03</td>
<td>2.27±0.04</td>
<td>3.00±0.03</td>
<td>1.85±0.08</td>
</tr>
<tr>
<td>Oxalate mg/100 g of dries matter</td>
<td>595.83±15.87</td>
<td>330.0±27.5</td>
<td>504.16±15.87</td>
<td>247.5±27.5d</td>
</tr>
</tbody>
</table>

Data are mean±SEM (n = 3); AE: aqueous extract; ME: methanolic extract; Values showing the same letter are not significantly different (p<0.05) from one other in the same line.

vegetables in the literature (Ibrahim et al., 2001; Hassan and Umar, 2006). Zinc is implied in the normal operation of the immune system.

The ratio of Na/K in the body is of great importance for the prevention of hypertension. A ratio of Na/K lower than 1 is recommended (FND, 2002). Consequently, the consumption of A. dubius, A. hybridus and A. viridis is advised with the patients suffering from hypertension.

Calcium and phosphorus are associated at the growth and the maintenance of the bones, the teeth and the muscles (Dosunmu, 1997; Turan et al., 2003). For a good intestinal absorption of Ca and P, the ratio of Ca/P should be close to 1 (Guil-Guerrero et al., 1998). A. dubius answers this requirement and would be certainly a good source of Calcium and especially of Phosphor for the body.
Functional activity: The antioxidant potential of the extracts would be responsible for the prevention of the cardiovascular and neurodegenerative diseases (Heim et al., 2002) and of the bones diseases (Govindarajan et al., 2005). It would prevent also cancers (Kawanishi et al., 2001).

The antioxidant activity of the AE of A. dubius, A. graecizans, A. hybridus and of A. viridis was evaluated with β-carotene bleaching assay and DPPH radical scavenge. The evaluation of the antioxidant activity of the extracts of the four species showed an activity dose dependent. Their CE50 are respectively 1.26, 1.43, 1.50, and 2.73 mg/mL for A. dubius, A. graecizans, A. hybridus and A. viridis. The antioxidant activity of α-tocopherol (EC50) used as control was of 0.49±0.01 mg/mL.

Our extracts reduce the discoloration of the β-carotene. In more we notice that A. dubius, A. graecizans and A. hybridus showed the same anti-oxidizing capacities and 3 times less than control. A. viridis was shown the least active. This would be due to the phenolic compounds and especially to the β-carotene whose A. viridis contains less.

The DPPH scavenging activities of the extracts, expressed as a μmol AEAC/g extract value, ranged from 33.67±2.06 at 66.99±1.65. These results showed a weak activity compared to quercetin (13760±0.26) used as control.

These plants are not a good source of natural antioxidant. Studies carried out by Ozsoy et al. (2009) could show that other species of the same family as Amaranthus lividus stems with leaves and flowers seem to be good sources of natural antioxidants.

The inhibition percentages of the XO go from 6.619±0.04% for A. graecizans to 24.35±0.02% for A. viridis. Compared with the inhibiting capacity of the allopurinol 93.2% at 100 μg/mL on XO, these extracts show a weak activity.

Phytochemistry: The extraction and the proportioning of polyphenols are a current practice in the evaluation of medicinal plants. The most significant content of polyphenol is found in the aqueous decoction extract of A. hybridus (12.73±1.61 mg GAE/100 mg of extract. The contents of phenolic of the four species are different and decrease respectively from A. dubius, A. graecizans, A. hybridus at A. viridis. Water extracts the compounds better than the methanol. It is also the food mode of use of these amaranths, as in sauces.

The most significant contents of flavonoids were observed in the AE followed by the ME. The proportion of flavonols is relatively significant. These flavonols including rutin would then have a dominating role in the action of the flavonoids.

Polyphenols, flavonoids, tannins and saponosides (Owen and Johns, 1999) would be potentials inhibiting of the XO. The low contents of polyphenols in these species would explain their weak inhibiting activity of the xanthine oxidase.

Anti-nutritive factors: The contents of tannin vary between 3.68 (ME of A. hybridus) and 1.25 mg TAE/100 mg (ME of A. graecizans).

The contents of tannin for 100 mg of dry vegetable material were evaluated. These rates vary between 0.024 (ME of A. viridis) and 0.066 mg/100 mg for A. hybridus. These values are definitely comparable with those reported by Fasuyi (2007) which are of 0.068 mg/100 mg of dried leaves for A. hybridus.

The proportioning of the tannin is interesting in human nutrition because they constitute an antinutritionnel factor. The high percentages of tannin would have a negative influence on the digestibility of proteins and the contribution in amino acids (Fasuyi, 2007).

Oxalate content: The oxalate content found varies between 247.50±27.50 and 595.83±15.87 mg/100 g of dry matter. A. dubius has the high content of oxalate. By taking account of the water content, A. hybridus contains approximately 84.02 mg/100 g of fresh matter. The oxalate content of A. hybridus corroborates work of Savage (2000) which found 90.9 mg/100 g fresh matter in the leaves of A. hybridus.

The oxalate content found varies between 247.50±27.50 and 595.83±15.87 mg/100 g of dry matter. A. dubius has the high content of oxalate. By taking account of the water content, A. hybridus contains approximately 84.02 mg/100 g of fresh matter. The oxalate content of A. hybridus corroborates work of Savage (2000) which found 90.9 mg/100 g fresh matter in the leaves of A. hybridus.

The oxalate content found varies between 247.50±27.50 and 595.83±15.87 mg/100 g of dry matter. A. dubius has the high content of oxalate. By taking account of the water content, A. hybridus contains approximately 84.02 mg/100 g of fresh matter. The oxalate content of A. hybridus corroborates work of Savage (2000) which found 90.9 mg/100 g fresh matter in the leaves of A. hybridus.

The oxalate content found varies between 247.50±27.50 and 595.83±15.87 mg/100 g of dry matter. A. dubius has the high content of oxalate. By taking account of the water content, A. hybridus contains approximately 84.02 mg/100 g of fresh matter. The oxalate content of A. hybridus corroborates work of Savage (2000) which found 90.9 mg/100 g fresh matter in the leaves of A. hybridus.

The oxalate content found varies between 247.50±27.50 and 595.83±15.87 mg/100 g of dry matter. A. dubius has the high content of oxalate. By taking account of the water content, A. hybridus contains approximately 84.02 mg/100 g of fresh matter. The oxalate content of A. hybridus corroborates work of Savage (2000) which found 90.9 mg/100 g fresh matter in the leaves of A. hybridus.

Our extracts reduce the discoloration of the β-carotene. In more we notice that A. dubius, A. graecizans and A. hybridus showed the same anti-oxidizing capacities and 3 times less than control. A. viridis was shown the least active. This would be due to the phenolic compounds and especially to the β-carotene whose A. viridis contains less.

The DPPH scavenging activities of the extracts, expressed as a μmol AEAC/g extract value, ranged from 33.67±2.06 at 66.99±1.65. These results showed a weak activity compared to quercetin (13760±0.26) used as control.

Our extracts reduce the discoloration of the β-carotene. In more we notice that A. dubius, A. graecizans and A. hybridus showed the same anti-oxidizing capacities and 3 times less than control. A. viridis was shown the least active. This would be due to the phenolic compounds and especially to the β-carotene whose A. viridis contains less.

The DPPH scavenging activities of the extracts, expressed as a μmol AEAC/g extract value, ranged from 33.67±2.06 at 66.99±1.65. These results showed a weak activity compared to quercetin (13760±0.26) used as control.

CONCLUSION

This study, reveals that Amara dubius Mart. ExThell Amaranthus graecizans L. Amaranthus hybridus L and A. viridis L. appreciably present the same chemical profile but with different amounts.
A. hybridus and A. dubius content the high level of mineral and proteins. The amounts of protein and micro elements of species explain their uses especially in the infantile nutrition as food supplement.

These four species usually used in food linked of the contents of natural substances with therapeutic virtues such as β-carotene, proteins and minerals. These four species could thus contribute considerably to fight pathologies of oxidative stress more and more running in developing countries. The everyday consumption of these amaranths could have a positive impact on pathologies like cancers, diabetes, hypertension and neurodegenerative diseases.

It is also advised a moderate consumption of these species for the people predisposed of the renal calculi, especially A. hybridus and A. dubius.

ACKNOWLEDGMENT

The authors acknowledge ONEA Central Laboratory in Burkina Faso and all the member of Laboratory of Biochemistry and Chemistry (LABIOCA) for technical support.

REFERENCES


