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# Nutrient, Mineral and Phytochemical Properties of Selected Underutilized *Amaranthus* Vegetable Species in Ekpoma, Edo State, Nigeria

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**Abstract**
**Food insecurity (characterised by poor nutrition) and ill health are interlinked problems which constitute major sustainable development challenges globally. Effective tackling of these challenges must, among other efforts, involve exploring and exploiting the nutrients and medicinal potentials of many underutilised indigenous vegetables. This study assessed the nutrient, mineral and phytochemical constituents of four different *Amaranthus* plants as a basis for establishing their nutritional and medicinal values. In dried and powdered forms, the plants were subjected to nutrient, mineral and phytochemical analyses using standard chemical methods. All the plants were found to contain appreciable amounts of proteins (16.94 – 194.47 mg/g), carbohydrates (5.12 – 16.74 mg/g), vitamin C (8.10 - 44.07 mg/g), beta carotenes (2.67 – 5.89 mg/g), crude fibre (3.81 – 4.47 mg/g), ash (2.11 – 19.08 mg/g), calcium (35.3 – 384 mg/g), iron (6.71 – 74.61 mg/g), magnesium (19.19 – 31.10 mg/g), zinc (2.84 – 31.84 mg/g) and potassium (10.86 – 50.80 mg/g). The vegetables contained alkaloids (except *A. spinosus* var. red), flavonoids, saponins, phenols, steroids (except *A. viridis*) and glycosides. *Amaranthus spinosus* var. green had the highest concentrations of 161.1 mg/g, 214.11 mg/g, 38.11 mg/g, 21.03 mg/g and 89.16 mg/g for alkaloids, flavonoids, saponins, steroids and glycosides respectively while *A. dubius* had the highest concentration (18.03 GAE) of phenols. The considerable good nutritional and phytochemical properties of the vegetables make them highly recommended for inclusion in diets and food products. The results of the study also indicate that the plants could be useful for new drug development and managing various ailments.**

**Keywords:** *Amaranthus,* Nutrients, Phytochemicals, Underutilised vegetable.

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## Introduction

The theme for the 2020 International Day for Biological Diversity rightly stated: "Our Solutions are in Nature" (Convention for Biological Diversity Secretariat, 2020). This emphasises the fact that in mankind's quest for solutions to sustainable development challenges such as pandemics, diseases and hunger, there is need to carefully and properly explore and exploit the free gifts of nature. Among these free gifts of nature which hold potential answers to diverse human challenges are the underutilised indigenous vegetables (UIVs).

Vegetables are rich sources of proteins, carbohydrates, fibre, vitamins and minerals. In addition to their nutritional significance, vegetables also contain phytochemicals which possess several medicinal properties. The Nigerian people are endowed with diverse vegetables which besides being nutrient-rich food source, can also serve as medicines for curing diverse ailments. According to Kadiri and Olawoye (2015) more than 40 indigenous leafy vegetables are eaten in Nigeria. However, some of these indigenous vegetables have been identified and classified as underutilised in 2013 (Nigerian Indigenous Vegetable Project, 2013).

Underutilised vegetables (UIVs) are indigenous vegetables rich in nutrients and phytochemicals, but with their nutritional and medicinal potentials yet to be well explored in ameliorating nutritional and health challenges. These crops grow in diverse agroecosystems according to Ayinde et al. (2016); and based on the reports of Pandy (2008), their neglect is not only peculiar to developing nations but is a global occurrence. Cultivation and appropriate consumption of these vegetables will go a long way in contributing to poverty alleviation and food security by providing income for farmers and solving micronutrients deficiencies as these vegetables are rich sources of vitamins, minerals and proteins necessary for maintaining the body and repairing worn-out tissues. According to Ayinde et al. (2016), UIVs are important in providing quick income to farmers and reducing poverty because of their short gestation periods. They further posited that if given appropriate attention by the government and other developmental stakeholders, UIVs could assume a more important role globally in the sustainable supply of diverse and nutrient-rich foods.

Food insecurity remains a growing challenge in developing nations with factors such as over-population, drought, climate change and the economic fallout of the COVID-19 pandemic exacerbating the problem in recent times. Despite the riches and technological advancement of the 21st century, all over the world, over a hundred and fifty million people are trapped in hardships imposed by hunger and malnutrition (FSIN, 2021). According to the FSIN report on world food security, the Democratic Republic of the Congo, Yemen, Afghanistan, the Syrian Arab Republic, the Sudan, Nigeria (15 states and the Federal Capital Territory), Ethiopia, South Sudan, Zimbabwe and Haiti were the nations having the worst food crises in 2020 (FSIN, 2021).

Tackling food insecurity and diseases efficiently must include among other measures, revisiting the neglected and underutilised crops (Baa-Poku, 2018). Underutilised vegetables have great potential for contributing significantly to the amelioration of "hidden hunger" caused by micronutrient deficiencies (Jimoh et al., 2022). Some of these plants are also useful as medicines and in other ways such as alternative raw materials for industries and ornamentals, for cultural purposes and as feed for livestock.

A look at the policies of many governments in Africa show that little value is given to indigenous vegetables and even in research institutions, emphasis and priority seem to be placed on conventionally cultivated species which are often cultivated using agrochemicals and artificial products (Adebooye and Opabode, 2004; Aina, 2005; Ayinde et al., 2016; Baa-Poku, 2018).

Among the underutilised vegetables in Nigeria are the amaranths, alongside other plants such as garden egg, snake tomato, glossy night shade, etc (Kadiri and Olawoye, 2015). Amaranth is the collective name used for vegetables belonging to the genus *Amaranthus*. They are among the oldest food crops in the world and they are well known because some of their species are food crops in different parts of the world (Itúrbide and Gispert, 1994; Muriuki et al., 2014; Baraniak and Kania-Dobrowolska, 2022). Notable species of *Amaranthus* in the tropics include *Amaranthus hybridus*, *Amaranthus dubius*, *Amaranthus cruentus*, *Amaranthus hypochondriacus* and *Amaranthus spinosus* (Jimoh et al., 2022).

Several characteristics mark out *Amaranthus* as important crops with high potential for boosting food security and ameliorating malnutrition in vulnerable communities. These characteristics include their high nutrient content, low production cost, easy adaptation to the environment they grow, tolerance to drought, and early maturation period (Wambugu and Muthamia, 2009; Jimoh et al., 2022). Through the cultivation of *Amaranthus*, poor individuals can also generate income thus boosting their financial independence.

Although there are several species and varieties of leafy *Amaranthus* in Nigeria, yet there is no enough knowledge on their different nutrients and phytochemical constituents. A search through available literature shows that most proximate and phytochemical studies on species of *Amaranthus* in Nigeria focus more on *A. hybridus* and *A. viridis*, while such studies on the other species of amaranths appear to be relatively scarce (Akubugwo et al., 2007; Onuminya et al., 2017; Ukom and Obi, 2018; Ogwu, 2020). As a result, only little of their potential nutritional and medicinal benefits have been tapped into. This study hence focuses on four different varieties of underutilised amaranths. The objective of this study was to investigate the nutrient, mineral and phytochemical constituents of four different amaranths, with the aim of better establishing their nutritional and medicinal values and peculiarity.

## Materials and Methods

*Collection and Identification of Specimens*

Fresh mature leaves of *Amaranthus spinosus* (green and red varieties) were collected around Ujoelen Extension quarters in Ekpoma (6°44'11''N 6°6'5''E). *Amaranthus viridis* was collected at two different locations on Ambrose Alli University campus namely FET large hall (6°44'12''N 6°4'46''E) and ETF Agric. building (6°44'20'' N 6°4'50'' E). *Amaranthus dubius* was collected behind the Engineering lecture hall (6°44'13''N 6°4'49''E) within the premises of Ambrose Alli University, Ekpoma. The plants were authenticated at the Herbarium in the Department of Botany, Ambrose Alli University, Ekpoma, Nigeria.

*Preparation of Plant Sample for Analyses*

Fresh leaves of each specie collected were washed, shredded and air dried for about two weeks in the laboratory. The dried leaves were milled into fine powder with a kitchen blender (Nakai Blender MX-228 Special) and stored in airtight plastic containers for further use.

*Chemical Analyses of the Samples*

Different nutrient, mineral and phytochemical parameters were analysed in the study. These parameters were carbohydrates, proteins, fibre, moisture, ash, beta carotene, total chlorophyll, total antioxidant capacity, calcium, zinc, magnesium, potassium, iron, alkaloids, steroids, terpenoids, saponins, flavonoids, anthraquinones, phenols and cardiac glycosides.

*Nutrient Analysis*

Carbohydrate was determined by measuring 1 ml of each vegetable sample extract into a test tube and adding 2 mL of anthrone solution; this was shaken well for 15 minutes and boiled for 30 minutes. It was then allowed to cool. The absorbance was read on the spectrophotometer (w4-uv-visible spectrometer) at 625nm. The carbohydrate concentrations in the sample were then extrapolated.

Protein was determined using the semi-micro Kjeldahl Method (AOAC, 1995). Ash content was determined by incinerating in a muffle furnace as described by AOAC (1995). Moisture was determined by AOAC (1995) method. Beta carotene was analysed by using column chromatography and UV-Spectrophotometry extraction was carried out using acetone and petroleum ether as described by Rodriguez-Amaya and Kimura (2004).

The ascorbic acid content in the samples was determined by High Profile Liquid Chromatography (HPLC) method as described by Vikram et al. (2005). Two grammes (2 g) of sample was weighed and extracted with 0.8% metaphosphoric acid. This was made up to 20 ml of juice. The juice was centrifuged at 10000 rpm. The supernatant was filtered and diluted with 10 mL of 0.8% metaphosphoric acid. This was passed through a 0.45 µm filter and 20 µL injected into the HPLC machine. Various concentrations of ascorbic acid standards were also made to make a calibration curve. The HPLC analysis was done using the Shimadzu UV-VIS detector. The mobile phase was 0.8% metaphosphoric acid, at 1.2 mL/min flow rate and wavelength of 266.0nm.

Total chlorophyll content was determined according to the method described by Lichtenthaler (1987). In it, 0.2 g of fresh leaves were blended and then extracted with 10 mL of 80% acetone and left for 15 minutes. The liquid portion was decanted into another test-tube and centrifuged at 2,500rpm for 3 minutes. The supernatant was then collected and the absorbance was then taken at 645/8nm, 663/2 and 470nm using a spectrophotometer. Calculations were made using the formula below:

Chl.a ($\mu g\ mL^{-1}$) = $12/25A_{663/2}-2/79A_{646/8}$;
Chl.b ($\mu g\ mL^{-1}$) = $21/50A_{646/8}-5/1A_{663/2}$
Chl. Total ($\mu g\ mL^{-1}$) = Chl.a + Chl.b

The results obtained were converted from µg $mL^{-1}$ to mg/g $^{-1}$ dry weight. Total antioxidant activity was done following methods adapted by Suseela et al. (2010). Tubes containing 0.2 mL of the extracts (100-500 µg/mL), 1.8 ml of distilled water and 2 mL of phosphomolybdium reagent solution (0.6 M sulphuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate) were incubated at 95°C for 90 minutes. Thus, the mixture was cooled to room temperature and the absorbance was measured at 695 nm. The antioxidant capacity was expressed as ascorbic acid equivalent. Crude fibre was determined using the AOAC (1990) standard methods. In it, two grammes (2 g) of dried powdered sample were digested with 0.25 M sulphuric acid and 0.3 M sodium hydroxide solution. The insoluble residue obtained was washed with hot water and dried in an oven (Memmert, Germany) at 100°C until constant weight. The dried residue was then incinerated, and weighed for the determination of crude fibre content.

*Mineral Elements Analysis*
The determination of minerals was done by dry ash and atomic absorption spectrophotometer (AAS) 55A atomic absorption spectrometer Agilent Technologies according to AOAC (1995). The minerals that were determined were calcium, magnesium, zinc, iron and potassium. Clean dry crucible was weighed and 5.0 g of the was sample weighed into it. The crucibles were placed on hot plates under a fume hood and the temperature increased slowly until smoking ceased and the samples were thoroughly charred. They were then put in a muffle furnace and temperature increased gradually to 2500$^{o}$C and heated for 1 hour. The temperature was increased to 5500$^{o}$C and incinerated to complete ashing. The temperature was then decreased to 300$^{o}$C, the crucibles was removed and cooled to room temperature. The ash was transferred quantitatively to a 100 mL beaker using 20 mL of 1N HCL, then heated at 80 – 90$^{o}$C on a hot plate for 5 minutes. This was then transferred to a 100 mL volumetric flask and filled to the mark using 1N HCL. Insoluble matter was filtered and the filtrate kept in a labelled polyethylene bottle. The absorbance values of the solutions were read by Atomic Absorption Spectrophotometer (AAS). The various mineral standards were also prepared to make the calibration curve.

*Phytochemical Analysis*
Total alkaloids were determined following the methods described by Harborne (1973). Flavonoid concentration was analysed using the Aluminum chloride colorimetric method (Jagadish et al., 2009). For the total phenolic compounds, 100 mg of the extract from the sample was weighed accurately and dissolved in 100 mL of triple distilled water (TDW). A 1.0 mL of this solution was transferred to a test tube, then 0.5 ml 2N Folin-Ciocalteu reagent and 1.5 mL of 20% $Na_2CO_3$ solution was added and ultimately the volume was made up to 8 mL with TDW followed by vigorous shaking and finally allowed to stand for 2 hours after which the absorbance was taken at 765nm. These data were used to estimate the total phenolic content using a standard calibration curve obtained from various diluted concentrations of gallic acid (Hagerman et al., 2000).

Total saponin was determined following the method of Obadoni and Ochuko (2001). Anthraquinone concentration was determined following the methods adopted by Soladoye and Chukuma (2012) while cardiac glycoside content was determined using Buljet's reagent as described by El-Olemy et al. (1994). Steroids were determined using the method by Narendra et al. (2013) and total terpenoid content was determined by colorimetry as described by Fan and He (2006).

## Results

*Nutritient Characteristics of the Vegetables*
Total carbohydrates, ash, crude fibre, beta carotene, ascorbic acid, total antioxidant capacity, protein and total chlorophyll content of the leaves of the different plants investigated are shown in Figure 1. *Amaranthus spinosus* var. green had the highest value (16.74 mg/g) of total carbohydrate, this was followed by *A. dubius* (14.91 mg/g) and then *A. viridis,* and the least was in *A. spinosus* var. red. *Amaranthus spinosus* var. green showed lower moisture content and higher protein content than the other species except *A. viridis* with the highest protein value (194.47 mg/g). The ash levels ranged from 2.11 mg/g in *A. spinosus* var. red to 19.08 mg/g in *A. viridis*. Findings from this study have also revealed that beta carotene (Vitamin A) content ranged from 2.67 mg/g to 5.89 mg/g (Figure 1). The ascorbic acid range was from 8.10 mg/g in *A. spinosus* var. red to 44.07 mg/g in *A. dubius*. Total chlorophyll values of the plants ranged from 42.46 mg/g in *A. viridis* where it was least to 61.08 mg/g in *A.*

*spinosus* var. green. Total antioxidant capacity values varied from 20.34 mg/g in *A. dubius* to 141.70 mg/g in *A. spinosus* var. green.

*Mineral Elements Composition*

The mineral elements investigated in this study are magnesium, zinc, potassium, calcium and iron. The mineral compositions of *A. spinosus* var. red, *A. spinosus* var. green, *A. viridis* and *A. dubius* are presented in Figure 2. The calcium levels recorded were relatively high ranging from 35.30 mg/g in *A. dubius* to 384 mg/g in *A. viridis*. The species *A. spinosus* var. red was found to have the highest level of iron (74.61 mg/g) while *A. spinosus* var. green recorded the lowest iron content of 6.71 mg/g.

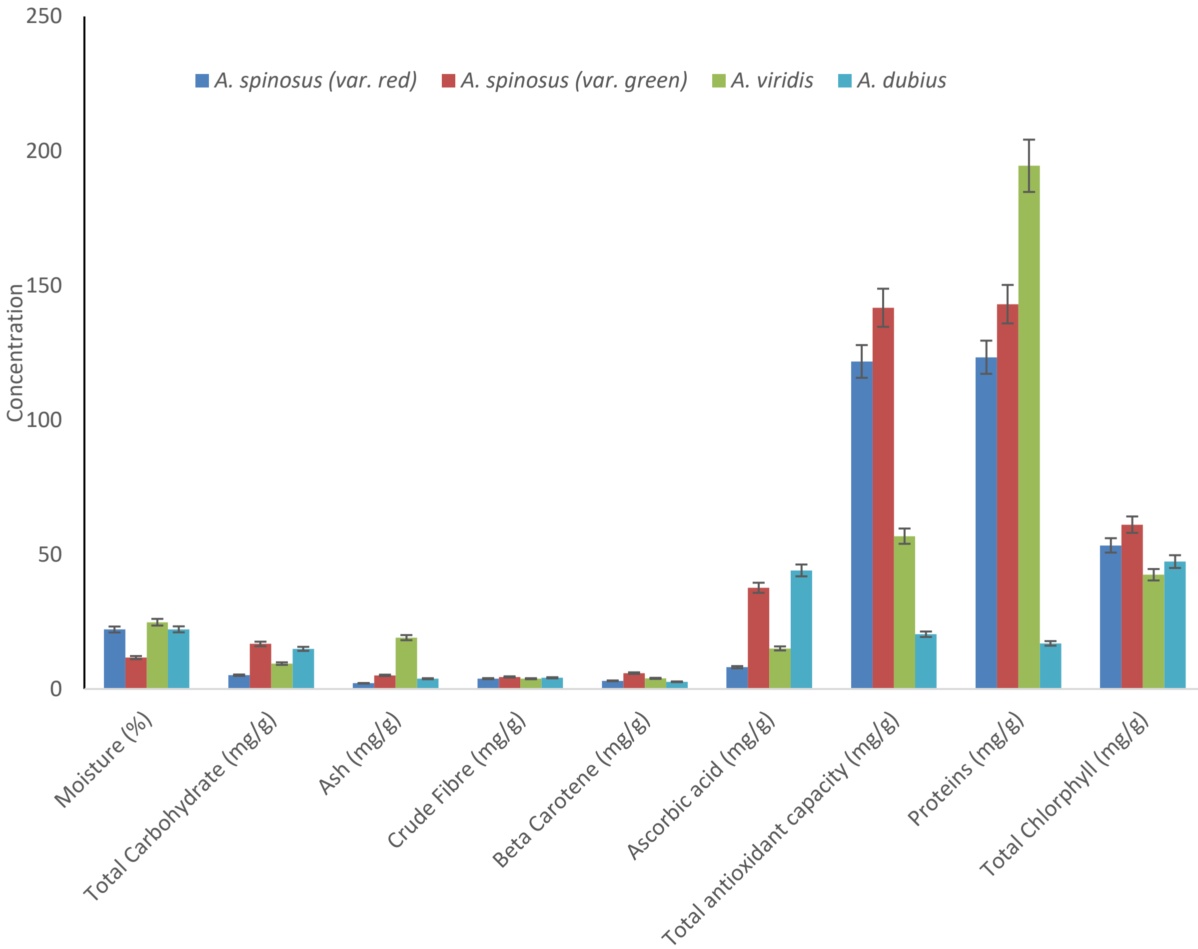


**Figure 1:** Proximate composition, beta carotene and total antioxidant capacity of underutilized *Amaranthus* species in Ekpoma, Edo State, Nigeria

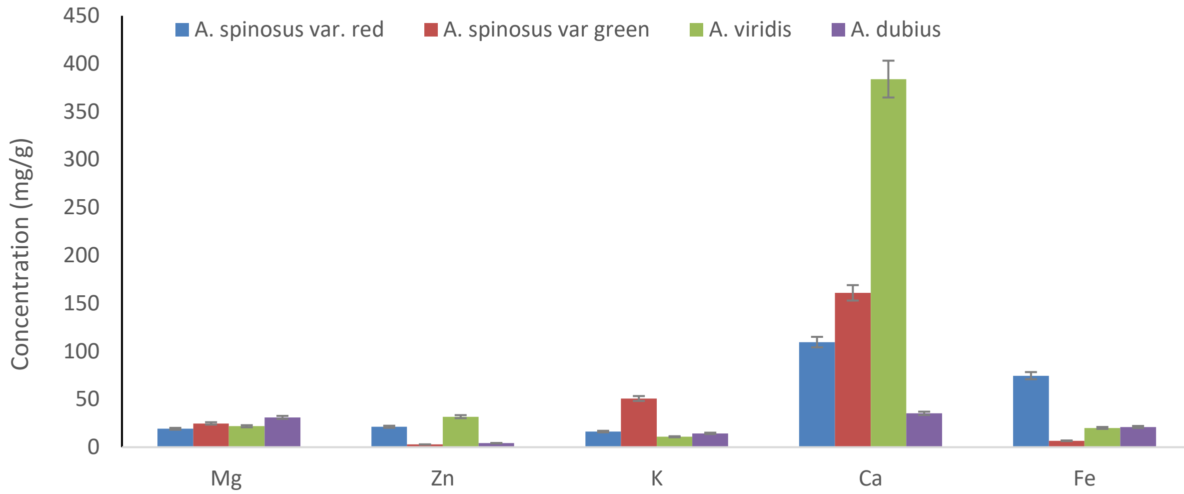


**Figure 2:** Mineral elements composition of underutilized *Amaranthus* species in Ekpoma, Edo State, Nigeria

Legend**:** Mg = magnesium, Zn = Zinc, K = Potassium, Ca = Calcium, Fe = Iron

*Phytochemical Composition*
Flavonoid's composition was found to be 214.11 with *A. dubius* having the highest composition of phenols (18.03 mg/g) and *A. spinosus* var. red having the least value (0.16 mg/g) (Figure 3). Alkaloids had the highest value of 161.10 mg/g in *A. spinosus* var. green and no trace in *A. spinosus* var. red (Fig. 3). Steroids were not detected in *A. viridis* but found present in the other plants. Terpene was not detected in three of the vegetables, namely *A. spinosus* var. green, *A. viridis* and *A. dubius.* In all the species investigated, anthraquinones were not detected.

**Discussion**
The considerable amounts of carbohydrate in all the vegetables studied is an indication that the leafy vegetables can be used to regulate various metabolic processes in the body as key molecules in the central metabolic pathways of the body. The degree of moisture content in a leaf is an important parameter which defines the rigidity or turgidity of the vegetable (Onuekwe, 2012). High moisture content results in rapid deterioration of vegetables and hence reduced shelf-life (Agbaire, 2011).

The substantial amount of fibre in all the vegetables show that they can help in keeping the digestive system healthy and functioning properly. Reports have shown that crude fibre plays a key role in lowering risk of constipation, diabetes and colon cancer (Ishida et al*.,* 2000; Muriuki et al., 2014). The high ash level in *A. viridis* implies that it would be a very good source of minerals. High ash values usually indicate high mineral composition (Onuekwe, 2012). The values of the ash detected in the vegetables indicate that they are good sources of minerals which are required for the day-to-day metabolic functioning of the body.

The highest protein value (194.47 mg/g) was obtained in *A. viridis* and this conforms with the report on amaranths by Achigan-Dako et al. (2014). However, accumulation of protein depends on factors such as increased atmospheric carbon dioxide, soil fertility and increased NaCl salinity. Leaves with high protein values are recommended for patients with protein deficiency diseases (Mensah et al., 2008). All the vegetables studied contained

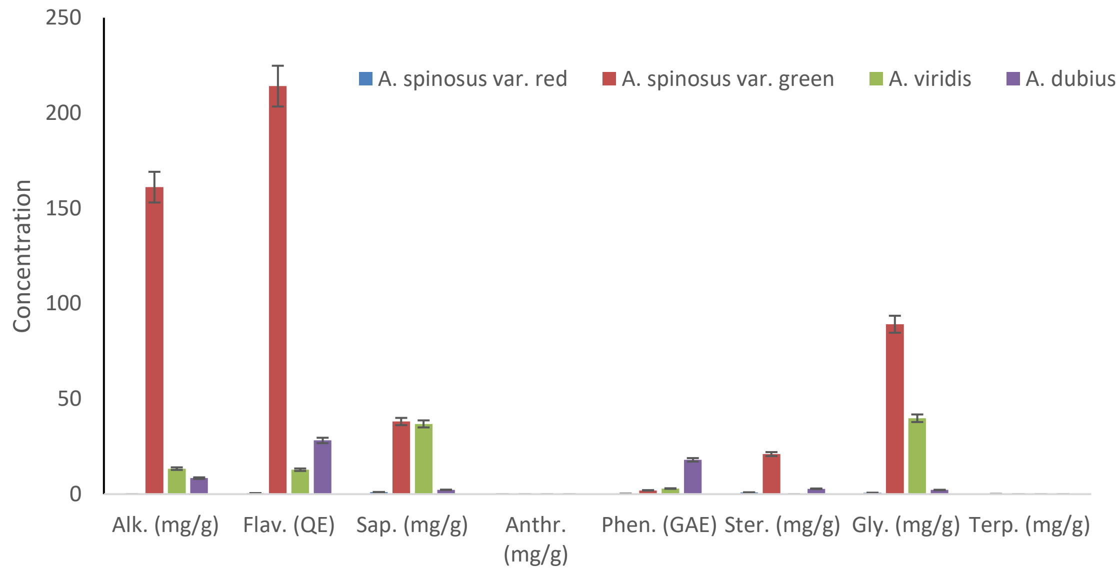


**Figure 3:** Quantitative composition of phytochemicals of studied *Amaranthus* species

Legend**:** Alk = Alkaloids, Flav = Flavonoids, Sap = Saponins, Anthr = Anthraquinones, Phen = Phenols, Ster = Steroids, Gly = Glycosides, Terp = Terpenoids.

appreciable amounts of protein which indicates that the vegetables can be used for building and repairing of body tissues, regulation of body processes and formation of enzymes and hormones (Patalinghug et al., 2022).

The loss of β-carotene during drying could have been caused by oxidation and catalysis by light. Ascorbic acid is a water-soluble vitamin, much of it could be lost during excessive washing or during processing, especially cooking, thus extra measures should be taken during processing like cooking to avoid loss of this vital micronutrient (Carr and Rowe, 2020). Daily intake of ascorbic acid even in quantities as low as 5 – 10 mg could help to prevent scurvy and improve physical well-being (Okwu, 2004; Carr and Rowe, 2020).

Leaf chlorophyll content (Chl) usually gives an index of the health of a plant. In line with the reports of Ramareddy (2002), the levels of chlorophyll depend on the chlorophyll stability pertaining to the habitat and ecological factors of any species. The antioxidant potential of the extracts is advantageous for the prevention of cardiovascular and neurodegenerative diseases, bones diseases and cancer (Heim et al., 2002; Govindarajan et al., 2005; Di Gioia et al., 2020).
The calcium content in most of the plants is higher than studies of Hanif et al. (2006) which showed 76 mg/100g calcium in spinach and 52 mg/100g calcium in cabbage. It is however comparatively low when compared to that of *Annona muricata* and *Vernonia amygdalina* (1118.30 mg/100g and 1264.18 mg/100g respectively) (Usunobun and Okolie, 2015a; 2015b). From the results, the richest source of calcium among the vegetables investigated is *A. viridis*, followed by *A. spinosus* var green, then *A. spinosus* var. red and lastly *A. dubius*. Calcium is one of the macro-minerals important for healthy growth and development. It is known to play a significant role in muscle

contraction, bone and teeth formation and blood clotting (Ahmed and Chaudhary, 2009; National Institutes of Health, 2021). The values of calcium observed from the study indicate that the vegetables could be really helpful in recovery from hypocalcemia and osteoporosis.

Potassium and magnesium are also important minerals for good health. Potassium and magnesium have been reported to be helpful in regulating high blood pressure. According to the Food and Drugs Administration (FDA) of the USA, the recommended daily value (DV) of magnesium is 420 mg (U.S. FDA, 2020). Magnesium is also an important mineral element in connection with circulatory diseases such as ischemic heart disease and calcium metabolism in bone (Ishida et al., 2000). High magnesium concentration is expected since magnesium is a component of leaf chlorophyll.

Zinc content obtained in the vegetables are comparatively high when considering those of *Anona muricata* and *Vernonia amygdalina* obtained in studies conducted by Usunobun and Okolie (2015a; 2015b). It has been observed that vegetables generally do not have a high concentration of zinc (Gutiérrez et al., 2008).

Micro-minerals such as zinc and iron are required in the body in amounts often below 100 milligrams per decilitre (U.S. FDA, 2020). According to the U.S. FDA (2020), recommended daily values for zinc and iron are 11 mg and 18 mg, respectively. The functions of zinc in the human body include supporting the immune system's healthy functioning, protein metabolism, aiding wound healing, cell growth and the breakdown of carbohydrate (Ibrahim et al., 2001). Values of iron obtained in this study are higher (6.71 - 74.61 mg/g) than findings of Srivastava (2011) who reported a range of 12.23 - 14.55 mg/100g iron in other amaranth species. Iron is a key element needed in the body for processes such as DNA synthesis and oxygen transport, and its deficiency leads to anaemia (Beard, 2001; Abbaspour et al., 2014). Flavonoids have been reported to exert a wide range of biological activities including antiviral, anti-inflammatory, antibacterial, antiallergic, cytotoxic, antitumor, treatment of neurodegenerative diseases and vasodilatory action (Tsuchiya, 2010). Good correlation between the total flavonoids content and antioxidant activity has been shown (Ayoola et al., 2008), indicating that flavonoids contribute in free radical scavenging. The presence of saponins in the plant leaves indicates their potential of improving the immune system when taken (Okwu, 2004). Saponins have also been shown to possess the ability of killing cancer cells and have also shown other medicinal properties, such as anti-inflammatory and anti-hyper-cholesterol (Trease and Evans, 1985; Lewis and Elvin-Lewis, 1995; Sharma et al., 2021; Baraniak and Kania-Dobrowolska, 2022).

The consumption of food and beverages rich in phenolics contents can reduce the risk of heart disease by slowing the progression of arteriosclerosis by acting as antioxidants towards low density lipoproteins [LDL] (Zhang et al., 2001). Cardiac glycoside in *A. spinosus* var. green was found to be relatively high. Cardiac glycoside influences the sodium potassium ion movement of cardiac membrane and have been used for treatment of congestive heart failure (Bejˇcek et al., 2021). However, the higher the concentration of these metabolites, the more dangerous they may become to health.

In line with reports of Airaodion et al. (2019), alkaloids may be used as analgesic and they have been reported to possess different pharmacological properties including antihypertensive effects (majorly indole alkaloids), antiarrhythmic effect, antimalarial activity (quinine) and anticancer actions (dimeric indoles, vincristine, vinblastine). Steroids have been reported to be efficient anti-plasmodium agents and are useful against cerebral malaria (David et al., 2004). The absence of steroids in *A. viridis* may have been due to environmental interactions between organisms and their environment.

Terpenes generally play an important role in plants often as signal compounds and phytohormones (Breitmaier, 2006). They are also useful as medicines and flavour enhancers. They are of tremendous importance in both nature and in human application (Yadav et al., 2014). Absence of anthraquinone in the plants, is in line with studies carried out by various researchers. Musharaf et al. (2011) carried out micro-chemical screening studies of *A. viridis* and found anthraquinone to be absent.

It must also be stated that factors such as climate, soil characteristics, cultural practises and crop variety and the period of analysis contribute to differences in mineral and chemical composition of crops (Muriuki et al., 2014; Burneo et al., 2021).

**Conclusion**

Results from this study have shown that each of the *Amaranthus* species investigated were rich in nutrients, minerals and phytochemicals. All the leafy vegetables contain calcium, magnesium, zinc, potassium, iron, proteins, carbohydrates, vitamin C, beta carotenes, crude fibre, ash alkaloids (except *A. spinosus* var. red), flavonoids, saponins, phenols, steroids (except *A. viridis*) and glycosides, in varying quantities. Terpenoids were present only in *A. spinosus* var. red while anthraquinones were not found in any of the vegetables. The concentration of the different phytochemicals investigated in *A. spinosus* var. red was found to be low. *Amaranthus spinosus* var. green on the other hand, had the highest concentration of alkaloids, flavonoids, saponins, steroids and glycosides, while *A. dubius* was found to contain phenols at the highest concentration. These results indicate that these vegetables have great potential for contributing to the solution of malnutrition and health challenges.

**Recommendation**

Serious attention should therefore be given to these vegetables in efforts made to combat food insecurity and diseases, as well as to improve human health. Governments at all levels, non-governmental organizations and relevant stakeholders should give priority to these vegetables in their policies. The cultivation of these vegetables commercially and in the home should be supported, their consumption should be widely encouraged, knowledge on the nutritional and medicinal benefits of the vegetables and how they can best be included in diets, utilised as medicines and used for other purposes should be disseminated. In addition, research on best agronomic practises for improved characteristics, high yield and palatability is recommended.

As mankind continues in its quest to find solutions and achieve the sustainable development goals, more attention should be given to preserving, exploring and exploiting nature sustainably.

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