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## **THE PHYSICO-CHEMICAL CHARACTERISTICS AND SOME NUTRITIONAL VALUES OF VEGETABLE AMARANTH SOLD IN NAIROBI-KENYA**

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Twenty one major supermarkets and ten independent green grocers in the city of Nairobi were surveyed for types of vegetable amaranths sold and their post harvest handling. The nutrient composition of the vegetables was also analyzed. In addition, information on three other traditional leafy vegetables (TLVs) namely, *Cleome gynandra*, *Solanum nigrum*, and *Vigna unguiculata* was obtained. All the vegetables were sold in bundles of average weight 0.45 kg. The edible fraction per bundle averaged 38.9%. Chemical analyses

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showed that vegetable amaranth had a moisture content of 85.5%, therefore a dry matter content of 14.5%. Expressed on dry matter basis, the mean total ash content was 19.2%, crude protein content 26.1% and the crude fiber content 14.7%. The mean ascorbic acid content was 627 mg/100 g, zinc content 5.5 mg/100 g and iron content 18 mg/100 g. The mean nitrate content was 732.5 mg/100 g, total oxalates 5830 mg/100 g and soluble oxalates 3650 mg/100 g, while the lead content averaged 1.03 mg/100 g. The study concludes that vegetable amaranth has potential as popular vegetable in the diets of Kenyans to significantly contribute to provision of micronutrients, particularly iron and zinc.

**KEYWORDS** traditional vegetables, marketing, postharvest handling, nutrition, Nairobi-Kenya

## INTRODUCTION

In Kenya, about 200 indigenous plant species are used as leafy vegetables (Maundu et al., 1999). Of these, only a few have been fully domesticated, while more are semi-domesticated, and majority are collected from the wild. The most commonly consumed traditional leafy vegetables (TLVs) in Kenya include the *Amaranthus spp.* (Pig weed), *Vigna spp.* (Cowpea leaves), *Solanum nigrum* (Black nightshade), *Cleome gynandra* (Cat's whiskers), *Cucurbita spp.* (Pumpkin leaves), and *Corchorus spp.* (Jute). These vegetables are either purchased or own grown for personal consumption. The vegetables have been reported to be particularly rich in vitamin A and iron, two nutrients that are currently believed to be deficient in the diet of people in many countries. The vegetables are also rich sources of vitamin C, proteins, fiber and the minerals sodium, phosphorus, calcium and zinc (Akindahunsi and Salawu, 2005; Orech et al., 2005). In addition to antioxidant vitamins, the vegetables also contain high contents of phytochemicals such as phenolic compounds, flavonoids and glucosinolates, which also possess strong antioxidant properties and which have been implicated in the prevention of aging related diseases such as cancer, arteriosclerosis, diabetes (Hertog et al., 1992), and in the management of HIV/AIDS.

It has been variously demonstrated that commercial production of traditional leafy vegetables by small scale enterprises can be a viable business model (Besong et al., 2001). Commercial production can serve as a useful tool for poverty reduction for women with little capital, limited access to land and working under labor constraints (Lewis, 1997). The revenue generated contributes significantly to enhancement of

household food security, access to family health care and enables women to attain a degree of financial independence from their husbands (IITA, 2003). Production of TLVs is very simple and is often done with very little input, save for occasional farmyard manure application. The vegetables are harvested by three methods: plucking only the leaves and edible parts, picking the tender branches; and cutting entire plants at close to the ground level or uprooting the plants. For marketing, the harvests are placed in bundles whose size is dependent on the harvest method.

The marketing and consumption of traditional leafy vegetables (TLVs) in Kenya has steadily changed over the past five or so years. The vegetables used to be sold mainly in the informal open air markets in most of the urban centers and were therefore presumed to be consumed mainly by the lower socio-economic groups. Recently, however, the vegetables have appeared for sale in increasing quantities in the supermarkets, where the middle and higher socio-economic classes do their shopping. In the supermarkets, the vegetables are sold alongside their exotic counterparts like cabbage and spinach, with which they must compete. This increase in the demand of TLVs has stimulated many people, especially women, to get involved in small scale growing and selling of these vegetables to improve their economic status. There exists, therefore, the opportunity to use traditional leafy vegetables to fulfill several goals including:

- 1) Expansion of the local food base
- 2) Improvement of community health and nutrition
- 3) Enhancement of food security, and
- 4) Generation of income and therefore reduction of poverty.

Amaranth is one of the vegetables for which consumption has greatly increased in the city of Nairobi in the recent past (Mwangi and Kimathi, 2006). Like other TLVs this vegetable used to be sold only in informal markets, but is now sold in supermarkets and green grocers. Nevertheless, the vegetable has an image problem as it is sometimes cultivated on the banks of drains carrying sewage and irrigated with water from these drains. This deters some consumers from purchasing these vegetables. Another problem is that there are many cultivars and races of amaranth in cultivation, and the growers, because of the small scale of their production, do not know which of these has the highest consumer acceptability. Lastly, once harvested the vegetable has a very short shelf-life.

The study of shelf-life is complicated because the vegetable is normally harvested in the three forms of leaves, tender young shoots or whole plants. It is likely that these three forms of the vegetable will have

different shelf-lives and different post harvest handling requirements. Finally, limited information exists on the nutritional quality and safety of any of the traditional vegetables commonly sold and consumed in Kenya. The safety of the vegetables raises problems not commonly encountered in agriculture because these vegetables are often grown in an urban setting. Lack of land for agriculture in the close to and within urban areas coupled with desire of many urban poor to generate income has resulted in some vegetables being grown on the banks of drains. This results not only in some consumers having a negative attitude to the vegetables, but raises the real risk of contamination by heavy metals and pathogens. For purposes of health and nutritional planning therefore, it is important to gain knowledge on the quality and safety of these commonly consumed foods.

Because of its presumed increasing role in the diets of Kenyans, it was the objective of this study to determine the percentage of amaranth, and its physico-chemical, and nutritional characteristics in relation to the main types of TLVs sold in the supermarkets and greengrocers in Nairobi.

## **MATERIALS AND METHODS**

Using a structured, previously tested questionnaire, a survey was carried out in 21 supermarkets (10 of the 'Nakumatt' chain and 11 of the 'Uchumi' chain) and 10 independent green grocers' stores in Nairobi. The survey determined the types of TLVs sold, the manner in which they were sold, their shelf life in the store, the unit cost per type, the distance from supplier, and the problems encountered in marketing the vegetables, then the types of amaranth in the market and the most popular type.

In addition, samples consisting of six bundles of each vegetable on sale at 10 of the stores (three of the 'Nakumatt' chain, four of the 'Uchumi' chain and three independent green grocers) were taken. Samples from each supermarket or green grocer were combined to form a batch. The samples were then placed in cool boxes (at approximately 4–6 °C) and transported to the laboratories of the Department of Food Science, Nutrition and Technology, University of Nairobi within two hours and prepared for analysis. The vegetables were analyzed for their edible proportion and the nutritional quality of this fraction.

## Preparation of the Vegetables for Analysis

The edible fraction of each batch was quantitatively separated from the hard stalks and other inedible parts. Each fraction was thoroughly mixed, and then samples were taken for analysis.

## Analytical Methods

Moisture content was determined by drying to constant weight at 60°C in a thermostatically controlled air-oven.

Crude protein was determined as total nitrogen by the semi-microKjeldahl method. The percent nitrogen was multiplied by an empirical factor of 6.25 to convert it to percent protein (AOAC, 1999).

Crude fiber and total ash contents were determined by AOAC methods (AOAC, 1999). Reduced ascorbic acid was determined by grinding 5 g sample mixed with 5 g acid-washed sand in a mortar and pestle with 100ml of 10% trichloroacetic acid until the mixture was homogenous. The homogenate was promptly titrated with a standard solution of 2,6-dichlorophenolindophenol dye solution (Tomohiro, 1990). The ascorbic acid content was calculated as mg per 100 g dry matter, against a standard solution prepared from pure ascorbic acid and titrated with the same standard dye solution.

The contents of iron, zinc and lead were analyzed in all the samples using Atomic Absorption Spectrophotometer (AAS) (Unicam 939/959, Pye-Unicam, Cambridge, UK) equipped with an air-acetylene flame and a hollow cathode lamp, and using lamps specific for each element. The device was operated under standard conditions using wavelengths and slit-widths specified for each element (AOAC, 1999). For analysis, 1 g of dried and finely ground sample was accurately weighed and incinerated to constant weight. The ash was extracted with 10 ml of HCl:water (1:1) and the extract was quantitatively transferred to 50 ml volumetric flask and made up to the mark. Appropriate dilutions were made and the elements analyzed against their standards.

For determination of total oxalate, the sample was extracted with 30 ml 1M HCl, while for soluble oxalate the sample was extracted with 30 ml distilled water, by shaking in a water bath at 100°C for 30 min in each case. This was followed by precipitation with calcium chloride. The suspension was centrifuged at 30 g and the supernatant discarded. After washing twice with 2 ml 0.35 M NH<sub>4</sub>OH, the pellet was dissolved in

0.5 M  $H_2SO_4$ . The solution was titrated with standard solution of 0.1 M  $KMnO_4$  at 60°C to a faint violet color that was stable for at least 15 seconds (AOAC, 1999).

For determination of nitrates, the samples were ground to pass through a 60µm sieve then re-dried in an air oven at 70°C overnight. Then 0.1g was weighed accurately and suspended in 10ml distilled water. The suspension was incubated at 45°C for 1 hour to allow complete leaching of the nitrate and then filtered through Whatman No. 41 filter paper. The filtrate was used for analysis of nitrate-N by the method of Cataldo et al. (1975)

### Data Analysis

Descriptive statistics were determined using MS Excel. Using the pivot table, depending on the type of data, means, standard deviations and/or frequencies were computed.

## RESULTS AND DISCUSSION

The survey data are shown in Table 1. The distance from the site of cultivation to the shop ranged from 21.9 km for *Amaranthus spp.* to 38.5 km for *Cleome gynandra*. The distance from supply is very important in vegetable production and marketing because the longer the transport time the greater will be the degree of product deterioration due to senescence and dehydration. Important factors influencing product deterioration per unit distance traveled are the method of transportation and the condition of the infrastructure.

The average number of bundles received by each store per day was highest for *Solanum nigrum*, at 88.9 and lowest for *Cleome gynandra* at 46.3. The weight of bundle was highest for *Vigna unguiculata* at 0.65 kg and lowest for *Cleome gynandra* at 0.42 kg. The percent edible portion per bundle varied between 38.9% for *Amaranthus spp* to 49.3% for *Solanum nigrum*. The price per bundle averaged KSh. 14.50 (about 0.2 USD) in the supermarkets/green grocers. The supermarkets and green grocers were buying from the farmer/traders at KSh. 10.00 (about 0.14USD) per bundle. This therefore translates to gross earnings of between KSh. 463.00 (6.6USD) and KSh. 889.00 (12.70USD) per delivery depending on the vegetable type. For the

Table 1. The types and characteristics of traditional leafy vegetable sold in supermarkets and groceries in Nairobi<sup>1</sup>

	Distance from supply (km)	No. of bundles received per day	Weight of bundle (kg)	Edible portion of bundle (%)	Price per bundle (KSh)	Bundles purchased by customers		Bundles spoilt per day (%)
						1-2	>2	
<i>Amaranth spp</i>	21.9 ± 8.1	75.2 ± 57.8	0.50 ± 0.1	38.9 ± 21.7	13.9 ± 2.2	11	20	5.5 ± 3.2
<i>Solanum nigrum</i>	31.4 ± 33.5	88.9 ± 88	0.47 ± 0.1	49.3 ± 5.4	14.4 ± 1.5	5	26	3.5 ± 2.9
<i>Cleome gynandra</i>	38.5 ± 64.4	46.3 ± 32.6	0.42 ± 0.2	40.5 ± 20.3	14.6 ± 1.9	9	20	3.1 ± 2.6
<i>Vigna unguiculata</i>	33.9 ± 20.8	71.2 ± 46.5	0.65 ± 0.2	41.1 ± 15.2	14.6 ± 1.8	9	20	4.2 ± 3.7

\*1US \$ = KSh. 70.00.

<sup>1</sup>Mean ± SD (N = 31).



three vegetables: *Solanum nigrum*, *Cleome gynandra*, and *Vigna unguiculata*. At Ksh. 13.90 per bunch, *Amaranthus spp* were the cheapest. Finally, the number of bundles that spoiled per day was highest for *Amaranthus spp.* at 5.5% and lowest for *Cleome gynandra* at 3.1%. It appears there was correlation between the number of bundles spoiling and those received each day. The number of bundles spoiling increased with increase in number of bundles received by the supermarkets/green grocers.

*Amaranthus spp.* and *Solanum nigrum* were sold in all the 31 stores studied while *Cleome gynandra* and *Vigna unguiculata* were sold in 94% of the sales outlets. Of all the traditional vegetables sold, consumers indicated a preference for *Amaranthus spp.* with most of them likening it to spinach. The other vegetables were less attractive than the *Amaranthus spp* because consumers indicated that they have a bitter taste. Only two species of amaranth; *Amaranthus hybridus* and *Amaranthus cruentus* were sold. *Amaranthus hybridus* (referred to locally as *kienyeji*) was sold in all the stores, while *Amaranthus cruentus* (which is referred to locally as *agriculture* because it is widely believed to be an agriculturally improved variety) was sold in 19 of the stores. There was a definite preference by the customers for *Amaranthus hybridus* compared to *Amaranthus cruentus*, which probably explains why the type was the most popular with the stores. The major reason for the preference given by almost all the supermarkets and green grocers surveyed was that because its broad leaves gave it a succulent appearance, *Amaranthus cruentus* was perceived by the customers to be grown using drain water heavily contaminated with sewage and hence was not fit for human consumption. If consumer education to dispel this misconception is carried out, consumption of the vegetable should increase.

The results indicate that in 20 out of the 31 outlets, customers purchased two or more bundles of amaranth (Table 1). Those who purchased one bundle of one type of vegetable indicated that they mixed the amaranth with other vegetables in cooking to reduce the pungency of vegetables like *Cleome gynandra* and *Solanum nigrum*. Two bundles of amaranth represent 0.51 kg of edible fraction, enough for one meal for an average family of eight members.

The vegetables were supplied directly by the growers to 28 outlets with some of the green grocers also growing their own vegetables, which they supplemented with those of other growers. The remaining outlets were supplied with the vegetables by middlemen. The main mode of

transportation of the vegetables by the suppliers to the stores was either by a lorry or pickup truck. For transportation, the vegetables were either packaged in crates or just stacked in the trucks and covered. The vegetables were received at all the sale outlets between 8h00 -10h00. On arrival, the vegetables were preserved by either holding them in a cold room (6–8 °C) or by holding them at ambient temperatures but with periodic sprinkling with cold tap water. It was reported by the stores that the vegetables could remain on sale for 2 days, although most of the supermarkets sold the vegetables only on the day of delivery. Of the 31 stores, only 5 reported selling all the vegetables they received. Others sold proportions ranging between 94% and 97% of the vegetables received based on the number of bundles reported as spoilt (Table 1).

For vending, the vegetables within each type were tied in bundles of similar average size. No formal packaging was used. The bundled vegetables were displayed by placing them in a trough which was nearly always at room temperature - between 19 °C and 24 °C at the time of survey. Only 1 out of the 31 stores surveyed displayed the vegetables at 6–8 °C. Wilting was the major cause of quality loss of the vegetables. Substantial losses also occurred through spillage of material onto the ground. It has been reported that leafy vegetables are easily preserved by storing them at temperatures close to 0 °C in packages which are impermeable to the diffusion of water vapor (e.g., polypropylene film) and which create a low O<sub>2</sub>/high CO<sub>2</sub> atmosphere (Favell, 1998). Packaging also helps to cut down on losses through spillage.

The main constraint to increased production of TLVs is the absence of any appropriate postharvest management to maintain quality. In the absence of this, they are highly perishable (as are most leafy vegetables in these circumstances) with a postharvest life of 1–2 days, which forces farmers to sell the product in local markets soon after harvest (Maundu et al., 1999), this requirement coupled with a poor road network limits the distance from the point of sale within which the vegetables can be grown. All the supermarkets covered in this study strove to sell all the vegetables within the day of delivery as whatever remained at the end of that day had to be discarded because it had already lost consumer appeal; a loss of outward appearance may be paralleled by a loss of nutritional quality, especially if yellowing has begun. Some groceries, however, especially those with refrigeration, could keep their TLVs for up to two days before they needed to be discarded due to quality loss. Also unlike the supermarkets, most of the groceries are not much

worried if their vegetables look somewhat wilted because of the type of clientele that they target. Their main target customers are the medium to low income groups, who are not very particular about freshness of the vegetables. So, at best the farmers need to deliver fresh harvests early each morning to the supermarkets and every other day to the green grocers. This is both expensive for the small scale farmers and limits the distance over which the vegetables can be marketed.

The farmers as well as the traders require simple postharvest treatments to help slow deterioration and maintain freshness. These technologies will help reduce the cost of delivery to the outlets for the farmers and allow the outlets to sell for longer periods of time. They will also benefit the consumers who buy more than their needs for one day and do not have refrigeration to store the surplus. Freshness of produce can be extended for limited periods by storage at low temperatures, modified atmosphere packaging and correct humidity (Kays, 1991; Favell, 1998). In addition, good sanitation in post harvest handling is important to prevent microbial contamination, which can accelerate quality deterioration of vegetables, especially in the humid tropical climates where the conditions for growth of spoilage organisms are always favorable. Low temperature handling and storage is, however, the most effective physical method of slowing postharvest deterioration of vegetables and other methods can be considered as supplemental (Wills et al., 1981; Kays, 1991).

The chemical composition of the raw vegetable amaranth at the point of sale is shown in Table 2, the results are expressed on dry weight basis. The results show that the vegetables had moisture content of 85%, representing a dry matter content of 15%. The protein content ranged between 24.7% and 27.3%. The crude fiber content varied from 13.9% to 15.5%. The total ash content ranged between 18.6% and 20.9%. The results also indicate vitamin C with levels of up to 627 mg/100 g, iron contents of 18 mg/100 g and zinc contents of 5.5 mg/100 g. These values are within the ranges reported previously (Dhan and Pal, 1991; Mwajumwa et al., 1991; Ricardo, 1993; Mathooko and Imungi, 1994; Murage et al., 1996) for raw amaranth leaves. Vegetable amaranth can therefore contribute substantially to protein, the specific minerals, vitamin C and crude fiber intake from diets. The levels of protein, ascorbic acid, iron and zinc are reduced in the cooked, drained vegetables (the form in which they are eaten) due to leaching of the nutrients into the cooking water. For example (Mathooko and Imungi, 1994) have reported loss of 80% ascorbic acid in cooked drained amaranth; Imungi

Table 2. Proximate chemical composition, ascorbic acid, iron and zinc contents of raw vegetable amaranth (*Amaranthus hybridus*) leaves<sup>1</sup>

Source	Moisture content (%)	Dry matter (%)	Crude protein (N × 6.25)	Crude fibre (%)	Total ash (%)	Ascorbic acid (mg/100)	Iron (mg/100 g)	Zinc (mg/100 g)
Uchumi	85.2 ± 1.4	14.8 ± 1.4	27.3 ± 0.7	15.5 ± 0.6	18.6 ± 1.1	444.9 ± 64.3	16 ± 3	5.6 ± 0.8
Nakumatt	86.7 ± 0.9	13.3 ± 0.9	24.7 ± 1.1	13.9 ± 0.5	19.1 ± 1.1	500 ± 118.7	16 ± 3	4.9 ± 0.34
Others	83.5 ± 0.9	16.5 ± 0.9	26.4 ± 2.6	15 ± 2.8	20.9 ± 3.3	627.6 ± 126.2	24 ± 2	6.3 ± 0.6
Mean	85.5 ± 1.6	14.5 ± 1.6	26.1 ± 1.7	14.7 ± 1.3	19.2 ± 1.7	503.5 ± 118	18 ± 8	5.5 ± 0.8

All values are expressed on dry matter basis.

<sup>1</sup>Mean ± SD (N = 6).

and Potter (Imungi and Potter, 1983) reported losses of about 12% of the protein, apparent increase of about 13% of the iron, loss of less than 1% of the zinc and loss of about 30% of the lead in cooked and drained cowpea leaves. The dietary intakes of these nutrients will therefore be lower by similar proportions in the cooked vegetables compared to the uncooked form. An adult person in Kenya will consume about 200 g of cooked amaranth vegetables per day, which contain about 7.6 g protein, 5.2 mg iron, 1.6 mg zinc and 182 mg vitamin C, assuming similar changes in the nutrient contents during cooking to those shown by cowpea.

It has been reported that Kenya's main nutritional problems include protein deficiency affecting a large proportion of the poor urban and rural populations. Iron deficiency induced anemia has also been reported to be prevalent among the general population, especially among children under five years of age and pregnant women (WHO, 2000). Considering even just these two headline, nutritionally related problems, the consumption of vegetable amaranth in diets would be expected to contribute to partly alleviating these problems. If similar change in the nutrient contents of the amaranth vegetables as reported for other leafy vegetables are assumed, consumption of equivalent of 200 g fresh weight of vegetable daily will contribute 14% and 17% Recommended Dietary Allowances (RDA) of protein for male and female adults respectively, 32.8% RDA of iron for both male and female adults. The RDA for protein will be reduced by about 50% and that of iron by about 30% in the case of lactating and pregnant mothers. The vegetables would also contribute 11% RDA for zinc in adult males and females, which will be reduced to 8% in pregnant women and 6.4% in lactating mothers.

Though amaranth is a valuable source of nutrients, the consumption of this vegetable (along with other TLVs) may pose some health risks due to the accumulation of anti-nutritional factors such as nitrates and oxalates, and possible contamination with toxic materials such as lead as a result of poor cultivation practices and/or pollution. The levels of nitrates, oxalates and lead in the vegetable amaranth samples are presented in Table 3. Values are expressed on dry matter basis. As Table 3 shows, the nitrate contents ranged between 505 mg/100 g and 1056 mg/100 g; this translates to about 73.2 mg to 153.1 mg/100 g fresh weight. These levels are much lower than those reported by (Kariuki, 1998) for *Amaranthus hypochondriacus*. Considering consumption of about 200 g per day of vegetable by adults, therefore, the daily intake of nitrates will be less than 146–306 mg. The maximum safe daily intake of nitrate

**Table 3.** Levels of Nitrates, Oxalates and lead in fresh vegetable amaranth (*amaranthus hybridus*) leaves<sup>1</sup>

Source	Nitrates (mg)	Total oxalates (mg)	Soluble oxalates (mg)	Pb (mg)
Uchumi	1056 ± 105	4860 ± 0.5	2840 ± 0.5	0.98 ± 0.3
Nakumatt	505 ± 190	6450 ± 0.4	3960 ± 0.5	0.85 ± 0.5
Others	540 ± 145	6550 ± 0.5	4200 ± 0.5	1.50 ± 0.6
General mean	733 ± 307	5830 ± 0.9	3560 ± 0.8	1.03 ± 0.5

All values are expressed on dry weight basis.

<sup>1</sup>Mean ± SD (N = 6).

recommended by WHO for adults is 220 mg ; equivalent to consumption of 208 g of fresh vegetable. Nitrates are water soluble and therefore some loss through leaching is possible in cooked vegetables if the cooking water is discarded (Ricardo, 1993). Abo Bakr et al., (1986) reported that 16% of the nitrate was lost from peas, 34% from beans, 51% from carrots and 34% from spinach (most comparable to amaranth), when these vegetables were boiled for unspecified times in water (vegetable: water = 1:2). This method of preparation leads to loss of most water soluble nutrients to varying extents during cooking (Imungi and Potter, 1983). The cooking method described is comparable to the traditional method in many Kenyan communities. This means that about 30% of free nitrates could be lost by leaching into the cooking water leading to reduced amounts in the cooked vegetables as consumed. If about 34% of the nitrate is lost during cooking (assuming amaranth behaves like spinach) then the safe limit for amaranth consumption increases to 314 g fresh weight equivalent of cooked vegetable for a person of 60 kg body weight (Mohri, 1993), which is much higher than the common daily consumption. Previously it has been proposed that that nitrate levels normally found in vegetable amaranths do not present a serious health problem to reasonably healthy individuals if consumption does not exceed 100 g of leaf per day (FAO, 1988), 50% of the typical daily intake of amaranth. Our calculations indicate that this limit may be excessively conservative. Most researchers have concluded that there is no danger of the daily nitrate intake exceeding the recommended daily allowance as a result of consuming amaranth considering the nitrate levels found in the vegetable and the daily consumption of the cooked vegetables.

The total oxalate content of amaranth was found to range between 4900 mg/100 g and 6600 mg/100 g. The soluble oxalate values were

between 2800 mg/100 g and 4200 mg/100 g. These levels are similar to those obtained by (Mziray, 1999) working with *Amaranthus hybridus* in Dar-es-Salaam, Tanzania., but are much lower than those reported by (Kariuki, 1998) in *Amaranthus hypochondriacus*. Oxalic acid is a major anti-nutritional factor which is widely distributed in plant foods (Gupta et al., 2005). It is known to interfere with calcium absorption by forming insoluble salts of calcium. Toxic levels to humans have been suggested to be 2 to 5 g of oxalic acid per day for populations consuming low levels of calcium (Ricardo, 1993). The levels of free oxalates found in the vegetables do not constitute a serious health hazard for reasonably healthy individuals if consumption does not exceed a maximum of 200 g of fresh leaf per day, equivalent to 29 g dry weight (FAO, 1988); which is below the amount required to cause health problems. Further, it is expected that if the method of cooking involves discarding of cooking water, the levels of free oxalates and therefore the levels of total oxalates in the vegetables as consumed will be substantially reduced.

As Table 3 shows, the levels of lead in the vegetables ranged between 0.98 mg and 1.5 mg per 100 g dry wt. Accumulation of heavy metals differ according to plant species (Hooda et al., 1997) the age of the plant, the environmental conditions in which the plant is grown and the part of the plant analyzed (Isabel and Concepcion, 1997), and the soil mobility of the particular metal ions involved. As lead is relatively immobile in the soil (<http://www.atsdr.cdc.gov/toxprofiles/tp13-c6.pdf>), leafy crops are most susceptible to contamination from atmospheric deposition of lead from industrial and automotive sources. The US Food and Drug Administration Advisory Panel suggest that no more than 1 mg of lead per day be consumed from food (Gordon and Wayne, 1993). However, under normal circumstances, the amounts of cooked vegetables consumed by individuals rarely exceed 100 g of fresh weight per day (FAO, 1988), much less than the 200 g assumed as the typical consumed per day. Moreover, if the cooking water is discarded, this amount is lowered by leaching into the cooking water. Imungi and Potter (1983) have reported loss of up to 30% lead during cooking of cowpea leaves by boiling in water. Assuming this type of loss in cooking, 200 g of the vegetables would then contain about 0.2 mg of lead. Therefore, the levels taken in with the cooked vegetables would not be high enough to warrant public health concern. Lead is a naturally occurring element found in the earth's crust. The element, however, occurs in low levels in food stuffs unless the foods are grown in sewerage and industrial effluents (David and Craig,

1994). The majority of dietary lead results from environmental pollution, especially if the food is grown near roads due to exhaust gases from automobiles, from processing equipment and storage containers fabricated using lead containing materials such as solder (Pyke, 1981; David and Craig, 1994)

In conclusion, the study showed that production, trade and consumption of vegetable amaranth in Nairobi is on the increase. Fresh cut amaranth vegetables are currently selling competitively with their exotic counterparts in the modern supermarkets and groceries. The most popular type of amaranth among consumers in Nairobi is *Amaranthus hybridus*. The study also showed that the vegetable amaranth has high levels of protein, vitamin C and the minerals iron and zinc that could help in overcoming micronutrient malnutrition at a negligible cost for developing countries. They also had high fiber content and hence would serve as a natural source of fiber. The levels of nitrates, oxalates and lead in the vegetables are not high enough to cause public health concern. Trade in fresh cut amaranth vegetable is, however, limited by its short shelf life. It is therefore recommended that simple and affordable post harvest handling practices that extend shelf life even for limited periods are developed.

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