Nutritional Profile of Amaranth Grain Varieties Grown in Kenya

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Abstract

Amaranth is an indigenous plant known for its leafy vegetables and grain. Efforts are increasingly being put forward toward increasing production and utilization of the crop. However there are gaps in knowledge and technology on nutritional diversity of different varieties grown in Kenya. The objective of this study was to finger print the nutritional diversity of grains from four (*A. hypochondriacus, A albus*, *A. cruentus,* and *A. hybridus*) different varieties grown in Kenya. Field evaluation was done by planting the varieties in the University farm. The composition of the grains was determined using recognized standard methods. There was no significant difference (P≤0.05) in composition of raw amaranth grain varieties. On average, amaranth grains were found to be rich in proteins 15.8%, lipids 7.5%, carbohydrate 66.0%, ash 3.3% and fiber 6.9%. The profile of amino acids and the specific content did not vary among different varieties. The highest amino acid on average was glutamic acid 7.2 (g/16 g of N) followed by aspartic acid 1.7 (g/16 g of N) and threonine 1.3 (g/16 g of N). Lysine occurred in appreciable amounts. The oil extracted from amaranth grain contained mainly unsaturated fatty acids. The predominant acids in the oil were oleic, linoleic and palmitic. Total unsaturated acids ranged from 76.2% to 77.6% and saturated fatty acids 22.4% to 22.8%. Linolenic acid was present in low concentration. The grains contain a high amount of iron (18.2 mg/100g), manganese (6.1 mg/100g) and zinc (3.8 mg/100g) among other minerals. The average level of anti-nutrients in grains were; phytate (254mg/100g), tannic acid (164mg/100g) and oxalate (194mg/100g) which are within levels that can be tolerated by the body system. This indicates that amaranth grain could be one of the pathways towards solving the macro - and micronutrient deficiencies experienced in Sub- Sahara Africa.

Keywords: Amaranth grain varieties, Nutritional diversity

1. Introduction

In Kenya grain amaranth was registered officially as a crop in 1991 by the Ministry of Agriculture. Since then its spread has been very slow perhaps owing to the low esteem with which it has been generally held. Now it is emerging that the crop could be the answer for those areas where finding a suitable cash crop has been a problem. As part of its Rapid Results Initiatives, the Poverty Eradication Commission is promoting amaranth as a cash crop that could help fight poverty (GTZ Sustainet, 2006). Amaranth has to date mostly been grown for its edible leaves which are a regular food component of most local community diets in the country. The nutritious grain element has largely been ignored. It is evident that the poverty level among the rural community can be reduced and the general living conditions of most people improved by amaranth grain production and introduction into commercial systems, however knowledge on the nutritional diversity of the common varieties is inadequate or missing. Consumption of grain amaranth is reported to have nutritional and health benefits. This range from a general improvement in well-being to prevention and improvement of specific ailments and symptoms including recovery of severely malnourished children and an increase in the body mass index of people formerly wasted by HIV/AIDS (Tagwira *et al*., 2006). The nutritional value of amaranth and environmental adaptability creates an excellent potential for the crop to positively impact on thousands of poor farmers who rely on staple crops that are often neither resilient nor nutritious (Monica *et al*., 2011). Amaranth is one of the few plants whose leaves are eaten as a vegetable while the seeds are used in the same way as cereals. There is no distinct separation between the vegetable and grain types since the leaves of young plants grown for grain can be eaten. The main species grown as vegetables are *A. tricolor, A. dubius, A. lividus, A. palmeri and A. hybridus while A. hypochondriacus, A. albus, A. cruentus and A. caudatus* are the main grain species (Teutonico and Knorr, 1985). This research presented an opportunity to fill the gaps in knowledge on the production performance of different varieties and their nutritional diversity. The species; *Amaranthus albus* and *Amaranthus hypochondriacus* are grain varieties which are grown commercially and therefore it was prudent to research more on their nutritional profiles. *Amaranthus cruentus* and *Amararanthus hybridus* mostly grow naturally and are mainly used as leafy vegetables.

2. Materials and methods

2.1 Research design

Grains of *A. hypochondriacus, A. cruentus, A albus and A. hybridus* varieties were collected from farmers in

Bondo, Lugari and Thika Districts. The grains were selected randomly, carefully sorted, dried and stored at 15^0C. Field evaluation was done by planting the four varieties at Jomo Kenyatta University of Agriculture Technology farm. Characterization included profiling the nutrients and anti-nutrient factors in raw grains. For each treatment, three samples were analyzed each in triplicate.

2.2 Determining nutrient composition of the grains

Moisture content was determined by the AOAC (1995) method 930.04. Total ash content according to AOAC methods 923.05, crude fiber was determined according to the AOAC (1995) method 920.86. Protein content was determined according to the AOAC 988.05 (3) method. Amino acid profile was determined using method described by Maria and Federico (2006), with modifications. Pre-column derivatization of amino acids with *o*-phthalaldehyde (OPA) followed by reversed-phase HPLC separation with fluorometric detection. Amino acids were detected based on the retention time established for the individual amino acid under defined experimental conditions. Calculation was based on the intensity established for a given amino acid of known concentration.

Crude lipid AOAC method 960.39 was used. Methyl esterification of lipids for fatty acids test by gas chromatography (GC) was done by refluxing 2-5 mg of oil in 2 ml of 95% methanolic hydrochloric acid (HCl) for 1 hour. Methyl esters formed were extracted thrice using 2 ml of n-hexane. A small amount of anhydrous sodium sulfate was added to the extract, to remove water. The solvent was evaporated to concentrate the extract to 0.3 ml using a stream of nitrogen. This was injected to the GC machine for the fatty acid profile. Identification of fatty acids was done by comparing with known methyl ester standards. The atomic absorption spectrophotometer (AAS) method was applied to determine mineral elements comprising calcium, iron, zinc, manganese and magnesium content (AOAC, 1995).

2.3 Determination of Anti-nutrient factors in amaranth grain

Analysis of phytic acid in amaranth grains was done by HPLC combining the column/mobile phase conditions established by Tanjendjaja *et al.*, (1980), with modification as detailed by Camire and Clydesdale (1982). Condensed tannins in the amaranth grains were determined using the Vanillin-Hydrochloric acid method (Burns, 1963; Price *et al.,* 1978). Determination of oxalates was by HPLC.

2.4 *Statistical analysis*

The data obtained was subjected to one way analysis of variance (ANOVA), using GENSTAT statistical package. Significant means were separated by Duncan's multiple range tests (Steel and Torries, 1980).

3. Results and discussion

3.1 Proximate composition of raw amaranth grains

Among the four varieties analyzed and considering the same moisture content, the average composition for carbohydrates, proteins and lipid was 66.0g, 15.8g, and 7.5g respectively (**Figure 1)**. There was no significant difference in proximate composition for the different varieties (P≤0.05). This balance of carbohydrates, fats, and protein, allow amaranth the opportunity to achieve a balanced nutrient uptake with lower amounts of consumption than with other cereals. From the results Amaranth grains are also a good source of fiber content.

3.2 Mineral composition of raw amaranth grain varieties

Results of the specific minerals indicate that there is no significant difference (P≤0.05) in the mineral content for different amaranth varieties (**Figure 2**). The results show that Grain amaranth is a good source of trace elements such as zinc (3.6 - 4.0mg/100g) and manganese (5.9 - 6.8mg/100g). People with AIDS are almost universally deficient of zinc, which contributes significantly to the continued decline of their already damaged immune systems. Stabilizing their immune function and reducing complications from the disease can be achieved by consumption of grain amaranth. The results show amaranth grain is a good source of iron (16.8-21.0 mg/100g) which is required by a number of enzymes that are required for oxygen metabolism. Iron-deficiency anemia reduces oxygen-carrying capacity and interferes with aerobic functions (Dallman, 1986). This makes the grains to be a very important source of balanced minerals. The calcium content is also note worthy.

3.3 Fatty acids composition of lipids from different amaranth grain varieties

The oil extracted from amaranth grain contains mainly unsaturated fatty acids (**Table 1**). The predominant acids in the oil are oleic, linoleic and palmitic. Total unsaturated acids ranged from 76.2% to 77.6% and saturated fatty acids 22.4% to 22.8%. Linolenic acid was present at low concentration. The percent unsaturation in amaranth fats is reported as 65% by Opute 1979, 74% by Lorenz 1985 and 76% by Saunder and Becker, 1984. These are comparable with the research findings, 76%. There is no significant difference (P≤0.05) between varieties. Amaranth oil provides an excellent source for omega series fatty acids. Berger et al., 2003 in a study of the cholesterol-lowering properties of amaranth grain and oil in hamsters, report that amaranth oil significantly reduced non-HDL cholesterol and raised HDL cholesterol, as well as lowering very low density lipoprotein cholesterol (VLDL cholesterol) by 21–50%. Amaranth grains can therefore be recommended as a functional food product for the prevention and treatment of cardiovascular diseases. The inclusion of amaranth oil in the diet contributes to an increase in the concentration of polyunsaturated fatty acids and effective natural

antioxidant supplement capable of protecting cellular membranes against oxidative damage (Martirosyan *et al.,* 2007).

3.4 Amino acids profile of raw amaranth grain varieties

The profile of amino acids and the specific content did not vary with changing variety. The highest amino acid on average was glutamic acid 7.2 (g/16 g of N) followed by aspartic acid 1.7 (g/16 g of N) and threonine 1.3 (g/16 g of N). Lysine occurred in appreciable amounts (**Table 2)**. The essential amino acids of major importance in the amaranth grain include histidine, threonine, methionine, isoleucine, leucine, phenylalanine and lysine. The amino acids values were consistent with the reported data (Colmenares and Bressani, 1990; Chávez-Jáuregui *et al.,* 2000; Teutonico and Knorr; 1985, Saunders and Becker, 1984).

3.5 Anti-nutrient factors in raw amaranth grains

Anti–nutrients results (**Figure 3**), falls within reported range for other amaranth species (Teutonico and Knorr 1985) show phytic acid contents of the samples in the range (204 – 302mg/100g) and tannins (150 – 210 mg/100g).

Both tannin and phytate determinations are important because of their alleged interference with mineral absorption (Rose 1982). Excessive amounts of phytic acid in the diet can have a negative effect on mineral balance because phytic acid forms insoluble complexes with Cu^{+2}, Zn^{+2}, Fe^{+3}, and Ca^{+2} at physiological pH values (Graf 1986, Nolan et al 1987) and, consequently, reduces the bioavailability of these minerals. Amaranth grains contain moderate quantity of oxalate (178 - 220mg/100g) and can therefore be consumed moderately on a regular basis. Too much of soluble oxalate in the body prevents the absorption of soluble calcium ions as the oxalate bonds the calcium ions to form insoluble calcium oxalate complex. People who have tendency to form kidney stones are advised to avoid oxalate-rich foods. On the other hand, people suffering from coronary heart disease are encouraged to consume moderate oxalate rich foods as it helps to reduce blood cholesterol (Savage, 2000).

4. Conclusion

It has been demonstrated that amaranth grains are nutritionally dense and are an important source of macro/micronutrients. Most grain amaranth varieties have a similar nutritional profile. The grains are a rich source of protein containing essential amino acids (lysine) absent in other starchy staple consumed in East Africa. The grain is also a rich source of fats of high quality. Grain amaranth has a huge potential in blended recipes due to its unique nutritional properties. A composite recipe containing the leaves and grain would provide a unique food product. There is a strong need to understand the consumer behavior and market acceptability of amaranth based products. More research is necessary on phytochemicals to establish if there are any differences within the varieties.

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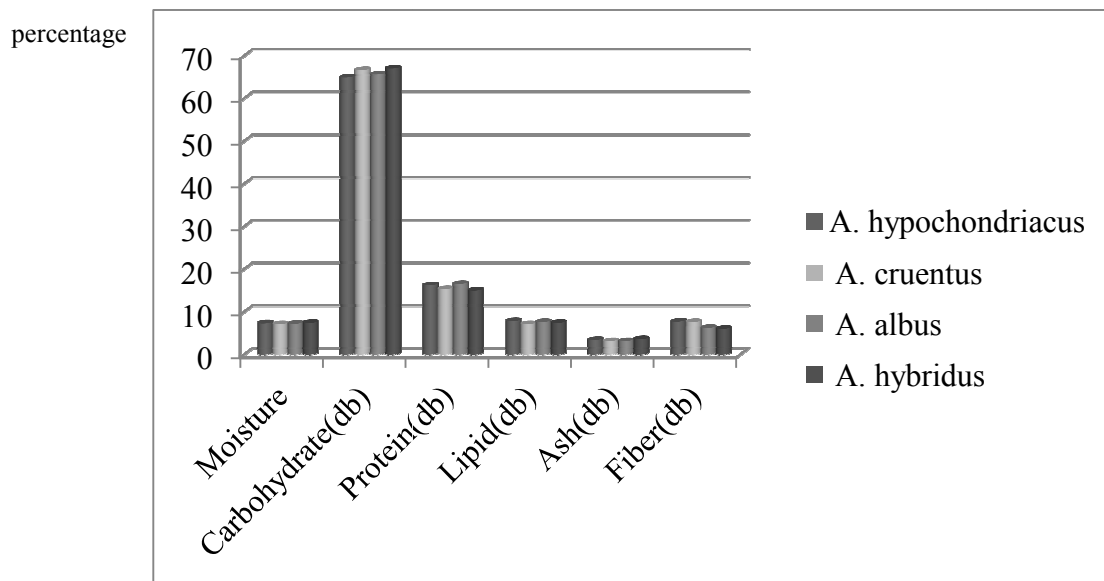
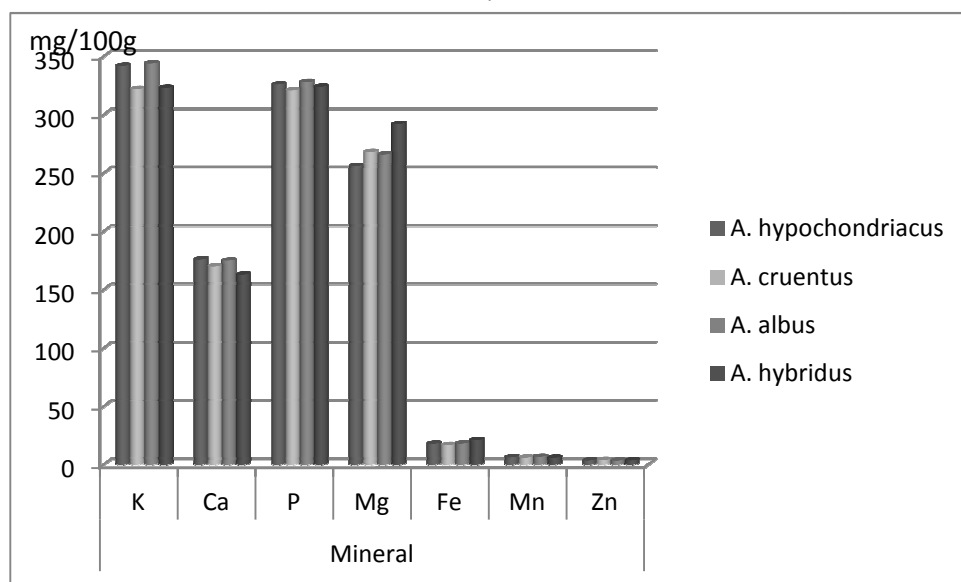**Figure 1 Proximate composition of raw amaranth grain varieties (grams/100 g)**

Figure 2 Mineral composition (dry weight basis) for different amaranth grain varieties (mg/100 g)

Fatty acids	Varieties				
	A. hypochondriacus	*A. cruentus*	*A. albus*	*A. hybridus*	SD
Lauric	0.5±0.01[a]	0.5±0.01[a]	0.6±0.01[a]	0.5±0.01[a]	<1.0
Myristic	0.1±0.01[b]	0.1±0.01[b]	0.2±0.01[b]	0.1±0.01[b]	<1.0
Palmitic	20.5±1.5[c]	20.7±1.6[c]	19.6±1.7[c]	20.7±2.3[c]	<1.0
Stearic	1.5±0.01[d]	1.5±0.01[d]	2.0±0.01[d]	1.5±0.01[d]	<1.0
Oleic	38.2±1.20[s]	38.8±1.8[s]	39.3±2.1[s]	38.2±2.2[s]	<1.0
Linoleic	37.5±1.20[a]	36.9±2.6[a]	36.4±1.6[a]	37.8±3.0[a]	<1.0
Linolenic	1.7±0.20[b]	1.6±0.20[b]	1.9±0.3[a]	1.7±0.20[b]	<1.0
% Satu. f.acids	22.6	22.8	22.4	22.8	<1.0
% Unsatu. f.acids	77.4	77.2	77.6	76.2	<1.0

 Table 1: Fatty acids composition of lipids from raw amaranth grain varieties (%)

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Means of two samples analyzed in triplicate ± Confidence interval. In each row means, followed by the same superscript are not significantly different (P≤0.05)

	A. hypochondriacus	*A. cruentus*	*A. albus*	*A. hybridus*	SD
Lysine	0.5±0.1 [b]	0.5±0.0[b]	0.6±0.0 [b]	0.5±0.0[b]	< 1
Threonine	1.4±0.0 [a]	1.1±0.0 [a]	1.2±0.0 [a]	1.3±0.0 [a]	< 1
Methionine	0.6±0.0 [c]	0.7±0.2 [c]	0.8±0.1 [c]	0.5±0.2 [c]	< 1
Isoleucine	0.6±0.0 [b]	0.5±0.0 [b]	0.7±0.0 [b]	0.5±0.0 [b]	< 1
Leucine	0.9±0.0 [a]	0.5±0.2 [a]	0.9±0.0 [b]	0.5±0.2 [a]	< 1
Phenylalanine	0.4±0.0 [s]	0.6±0.2 [s]	0.5±0.0 [s]	0.6±0.2 [s]	< 1
Histidine	0.6±0.0 [a]	0.5±0.0 [a]	0.6±0.0 [a]	0.4±0.0 [a]	< 1
Aspartic acid	1.7±0.1[s]	1.6±0.1[s]	1.8±0.1[s]	1.6±0.1[s]	< 1
Glutamic acid	7.1±0.2 [b]	7.7±0.2 [b]	7.0±0.0[b]	6.9±0.2 [b]	< 1

Table 2: Amino acids composition of raw amaranth grain varieties (g/16 g of N)
Means of two samples analyzed in triplicate ± Confidence interval
In each row means, followed by the same superscript are not significantly different (P≤0.05)
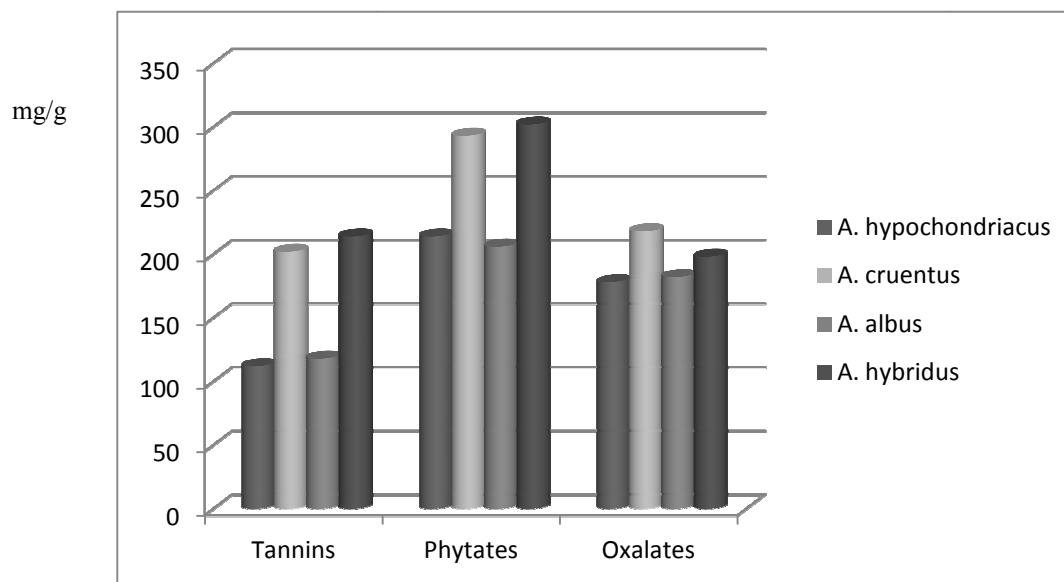
Figure 3: Anti-nutrient factors in raw amaranth grains (mg/100g dwb)