

DETERMINATION OF GROWING CAPABILITY AND NUTRITIONAL CONTENTS OF GRAIN AMARANTH FOR FOOD SECURITY AND HEALTHY LIVING IN NIGERIA

¹Abolaji, G.T*, ¹Olooto, F. M., ²Ogundele, D. T., and ³Williams, F. E.

¹*Department of Agricultural Economics and Extension Service, College of Agriculture and Veterinary Medicine, Kwara State University, Malete, Nigeria*

²*Department of Chemical, Geological and Physical Sciences Chemistry Unit, Kwara State University, Malete, Nigeria*

³*Department of Clinical Pharmacy and Pharmacy practice, University of Ilorin, Ilorin, Nigeria.*

*Corresponding author Email: drgracea@hotmail.com or grace.abolaji@kwasu.edu.ng

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ABSTRACT

Grain amaranth has multiple benefits as complementary and supplementary food and medicine respectively. The study focused on determining the nutritional and medicinal properties of grain amaranth cultivar obtained from REAP in Kenya which was propagated in Kwara State, Nigeria; harvested after 65 days; and prepared as samples for the study. Standard procedures of Association of Official Analytical Chemists (AOAC), Atomic Absorption Spectrophotometer, Flame Photometer, and Spectrophotometer. were used to determine the macro/micronutrients in the grains. Results revealed that the grains contained good source of protein, lipid, Iron-66 mg/100g, Zinc-11.34 mg/100g, Calcium-78.7 mg/100g, Manganese-37.1 mg/100g, Magnesium-2845 mg/100g, Potassium-400 mg/100g; Thiamine-0.2756 mg (%), Riboflavin-0.734 mg (%) and Niacin-1.042. Zinc is reported to contribute to boosting the immune system of people with AIDS and iron is required by enzymes for oxygen metabolism that reduces anemia. Multi-benefits of amaranth range from improved well-being to recovery of severely malnourished children; increased body mass index of people formerly wasted by HIV/AIDS; environmental adaptability, yield, and recipes development. More research efforts are needed on growing, inclusion in diets, consumer behavior and market acceptability of amaranth based products in order to contribute to the efforts of addressing food security, poverty reduction, nutritional, and medicinal needs of vulnerable communities.

Keywords: Complementary Food, Cultivar, Macro/micronutrients, Recipes , Well-being,

INTRODUCTION

Alternative crops are plant species that are used traditionally for their food, fiber, fodder, oil or medicinal properties. They have an under-exploited potential to contribute to food security, nutrition, health, income generation and environmental services. The pseudo cereal grain amaranth (*Amaranthus cruentus*) is one of such alternative crops. Grain amaranth is a fast growing, high yielding, stress resistant, nutritious crop with potential to contribute to the alleviation of poverty and malnutrition.

As indicated by Tung (2010), amaranth green leaves are commonly eaten boiled by many countries in West Africa. Its mild flavor and tender texture complements many starchy dishes and as a nutritious vegetable, amaranth leaves are high in vitamins A, K, B6, C, riboflavin and foliate; and essential minerals including calcium, iron, magnesium, phosphorus, potassium, zinc, copper, and manganese. Due to its high iron content, it is recommended for those at risk for anemia and as an important source of protein, some African populations rely on amaranth leaves for as much as 25 percent of their daily protein intake during its growing season. With a toasted flavor similar to popcorn when cooked, amaranth seeds are small in size but a good source of carbohydrate and protein (15-17 percent by weight). It is rich in the amino acids methionine, cycteine and has the highest content of lysine compare with all grains. It also has three times the fiber of wheat.

In the Home remedies (2008) report, it was pointed out that amaranth has various health benefits and medicinal properties which include but not limited to preventing retarded growth in children, increasing the flow of breast milk, preventing premature ageing, important in all bleeding tendencies, treating leucorrhoea, considered highly beneficial in treatment of gonorrhea and benefits patients with cardiovascular disease. According to Agong (2006), in South America grain amaranths are traditionally used in medicine, folk festivals, and as dye sources. Bink and Belay (2006) also indicated that in East African countries like Ethiopia and Peru, grain amaranth

are used as food; preparation of local beverage; added into porridge; and ground seeds are mixed with other grains to prepare pancake-like bread (*injera*).

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). According to Martirosyan, *et al.*, (2007), 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. Thus, 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).

However, its production and consumption in the country is dismal. This research seeks to promote the need for production and utilization of grain amaranth in Kwara state Nigeria, as a strategy to improve food security and nutrition. Also, the grain amaranth has a prominent role in human health and this study was, therefore, initiated to know the proximate composition, mineral and vitamin contents of grains amaranth in order to evaluate its nutritional and medicinal importance.

MATERIALS AND METHODS

Seeds of grain amaranth obtained from REAP Nairobi Kenya was planted in Ilorin Kwara State Nigeria and harvested after 65 days of propagation. For its proximate composition; mineral and vitamins analysis; the harvested grains was dried and ground to powdered form by using a grinder. The Proximate composition was determined by bringing the samples to uniform size and analyzed for moisture, protein, fat, ash, fiber and carbohydrate by the methods of AOAC (2003). The Moisture was determined by oven drying method. 1.5 g of well-mixed sample was accurately weighed in clean, dried crucible (W1). The crucible was introduced into an oven at

100-105°C for 6-12 hr. until a constant weight was obtained. Then the crucible was placed in desiccators for 30 min to cool. After cooling, it was weighed again (W2). The percent moisture was calculated:

$$\% \text{Moisture} = \frac{W1 - W2}{\text{Wt. of sample}} \times 100 \quad \text{Where}$$

W1 = Initial weight of crucible + Sample

W2 = Final weight of crucible + Sample

Note: Moisture free samples were used for further analysis.

For the determination of ash, clean empty crucible was placed in a muffle furnace at 600°C for an hour, cooled in desiccator and then weight of empty crucible was noted (W1). One gram of each of sample was taken in crucible (W2). The sample was ignited over a burner with the help of blowpipe, until it is charred. Then the crucible was placed in muffle furnace at 550°C for 2-4 hr. The appearances of gray white ash indicate complete oxidation of all organic matter in the sample. The crucible was cooled and weighed (W3). Percent ash was calculated

$$\% \text{Ash} = \frac{\text{Difference in wt. of Ash}}{\text{Wt. of sample}} \times 100$$

Difference in wt. of ash = W3 - W1

Protein in the sample was determined by Kjeldahl method. 0.5-1.0 g of dried samples was taken in digestion flask. Add 10-15 ml of concentrated H₂SO₄ and 8g of digestion mixture i.e. K₂SO₄ and CuSO₄ (8:1). The flask was swirled in order to mix the contents thoroughly then placed on heater to start digestion till the mixture become clear (blue green in color) for 2 hr. The digest was cooled and transferred to 100 ml volumetric flask and volume was made up to mark by the addition of distilled water. Distillation of the digest was performed. Ten milliliters of digest was introduced in the distillation tube then 10 ml of 0.5 N NaOH was gradually added through the same way. Distillation was continued for at least 10 minutes and NH₃ produced was collected as NH₄OH in a conical flask containing 20 ml of 4% boric acid solution with few drops of modified methyl red indicator. During distillation yellowish color appears due to NH₄OH. The distillate was then titrated against standard 0.1 N HCl solution till the appearance of pink color. A blank was also run through all steps as above. Percentage crude protein content of the sample was calculated by using the following formula:

$$\% \text{ Crude Protein} = 6.25 * \text{ x } \% \text{N} (*. \text{ Correction factor})$$

$$\% \text{N} = \frac{(S - B) \times N \times 0.014 \times D \times 100}{\text{wt. of sample} \times V} \quad \text{Where}$$

S = Sample titration reading

B = Blank titration reading

N = Normality of HCl

D = Dilution of sample after digestion

V = Volume taken for distillation

0.014 = Milli equivalent weight of Nitrogen

Dry extraction method for fat determination was employed. It involved extracting dry sample with some organic solvent, since all the fat materials e.g. fats, phospholipids, sterols, fatty acids, carotenoids, pigments, chlorophyll etc. are extracted together therefore, the results are frequently referred to as crude fat. Fats were determined by intermittent Soxhlet extraction apparatus. Crude fat was determined by ether extract method using Soxhlet apparatus. Approximately 1g of moisture free sample was wrapped in filter paper, placed in fat free thimble and then introduced in the extraction tube. Weighed, cleaned and dried receiving beaker was filled with petroleum ether and fitted into the apparatus. Water and heater were turned on to start extraction. After 4-6 siphoning ether was allowed to evaporate and disconnect beaker before last siphoning. The extract was transferred into clean glass dish with ether washing and was evaporated on water bath. The dish was placed in an oven at 105°C for 2hours and cooled it in desiccators. The percentage crude fat was determined.

$$\% \text{ Crude Fat} = \text{wt. of ether extract} \times 100 / \text{wt. of sample}$$

A moisture free and ether extracted sample of crude fiber made of cellulose was first digested with dilute H₂SO₄ and then with dilute KOH solution. The undigested residue collected after digestion was ignited and loss in weight after ignition was registered as crude fiber.

Nitrogen Free Extract (NFE) was calculated by difference after analysis of all the other items' method in the proximate analysis.

$$\text{NFE} = (100 - \% \text{ moisture} + \% \text{ crude protein} + \% \text{ crude fat} \\ + \% \text{ crude fiber} + \% \text{ ash})$$

The percentage calories in selected sample was calculated by multiplying the percentage of crude protein and carbohydrate with 4 and crude fat with 9. The values were then converted to calories per 100gm of the sample. Mineral contents of grain amaranth were determined by atomic absorption spectrometry, flame photometry and spectrophotometry according to the methods of AOAC (2003).

RESULTS AND DISCUSSION

Propagation and growing of Grain Amaranth

As shown in Figure I, the grain amaranth seeds obtained from REAP Nairobi Kenya Seminar was successfully propagated to produce seedlings that were transplanted and nurtured to maturity. Grains harvested after 65 days of propagation provided raw materials for sampling. The samples were used to determine the nutritional and medicinal contents of the grain amaranth grown in Kwara state. Thus, the results indicated that grain amaranth could easily be grown, early maturing and produce high yield of grains in Kwara State, Nigeria.



Figure I: Grain amaranth seedlings in a medicinal plant garden, Ilorin Kwara State, NIGERIA

Proximate composition of raw amaranth grains:

As shown in Table 1, the grain amaranth in this study is rich in proteins (19.85%); carbohydrate (77.82%); ash (2.25%); dietary fiber (1.81%); fat (1.79%); and energy (322 kcal/100g). The proximate composition values obtained in this study had similar or better values compared to Stephen, *et al.*, (2013) findings that indicated that on the 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%.

Table 1: proximate composition of Grain Amaranth

Nutrient	% composition
Moisture	6.49
Ash	2.25
Protein	19.85
Fat	1.79
Dietary Fiber	1.81
Carbohydrates	77.82
Energy	322kcal/100g

As concluded in Stephen, *et al.*, (2013) findings, the 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. And that this could also be one of the pathways towards solving the macro - and micronutrient deficiencies experienced in Sub- Sahara Africa. Also, Tagwira *et al.*,(2006) reported that consumption of grain amaranth provide nutritional and health benefits that include general improvement in well-being such as severely malnourished children recovered; and prevention and improvement of specific ailments and symptoms like people that were wasted by HIV/AIDS increased in their body mass index. Thus the proximate contents of protein, carbohydrate, fat, ash and energy showed that the grain amaranth in this study was loaded with balanced nutrients that could enhance healthy living and food security.

Mineral composition of raw amaranth grain:

As shown in Table 2, the Zinc (11.1/100g) and manganese (5.71/100g) values obtained in this study was similar or better than those of Stephen, *et al.*, (2013) study results of zinc (3.6 - 4.0mg/100g) and manganese (5.9 - 6.8mg/100g). As they indicated, people with AIDS are almost universally deficient of zinc, which contributes significantly to the continued decline of their already damaged immune systems. Therefore, consumption of grain amaranth could stabilize their immune function and reduce complications from the disease. Also, the results in this study showed that amaranth grain is a good source of iron (66.0 mg/100g) compared with the 16.8-21.0 mg/100g obtained by Stephen *et al.*, (2013) and iron (13.0 mg/100g) and zinc (4.8 mg/100g) obtained by Mburu, *et al.*, (2012). It was pointed out that Iron is required by a number of enzymes that are required for oxygen metabolism and its deficiency anemia reduces oxygen-carrying capacity and interferes with aerobic functions.

Table 2: Mineral composition of Grain Amaranth

Minerals	Amount in mg/100g
Iron	66.0
Zinc	11.3
Calcium	178.7
Magnesium	284.5
Manganese	5.71
Potassium	400.5

Other minerals of importance in the grain amaranth identified in this study included potassium (400 mg/100g); calcium (178.7 mg/100g); and magnesium (284.5 mg/100g) which

were higher values except for calcium when compared to those obtained from Mburu, *et al.*, (2012); grain amaranth product that had potassium (324.4 mg/100g), calcium (189.1 mg/100g), magnesium (219.5 mg/100g) respectively. They concluded that considering amaranth grain product fed to infant three times a day, at a reconstitution of 15% product, the levels of magnesium, manganese and tocopherols were far above the recommended intakes. Therefore, the grain amaranth in this study is loaded with essential minerals especially zinc and iron that could stabilize immune function and reduce complications from HIV/AIDS and anemia diseases respectively; and magnesium and manganese that are crucial for infants growth and development.

Vitamin composition of raw amaranth grain:

Niacin concentration was similar to 0.9 mg/100g sample, as reported for *A. cruentus* by other researchers (FAO/WHO, 2002 and Martirosyan, *et al.*, 2007), while thiamine, riboflavin and pyridoxine were higher and ascorbic acid was lower. Niacin is important for proper blood circulation and the healthy functioning of the nervous system. Niacin helps to maintain the normal functions of the gastro-intestinal tract and is essential for the proper metabolism of proteins and carbohydrates. Niacin also helps to maintain a healthy skin and dilates the blood capillary system. Thiamin (vitamin B1), a water-soluble vitamin, is needed by infants to help the body release energy from carbohydrates during metabolism and plays a vital role in the normal functioning of the nervous system.

Table 3: Vitamins in Grain Amaranth

Vitamin	mg%
Thiamin	0.276
Riboflavin	0.734
Niacin	1.042

Fatty acids composition of lipids from different amaranth grain varieties

The total unsaturated acids ranged from 76.2% to 77.6% and saturated fatty acids 22.4% to 22.8%. Amaranth oil provides an excellent source for omega series fatty acids and can therefore be recommended as a functional food product for the prevention and treatment of cardiovascular diseases. Also, FAO/WHO (2002) joint report indicated that the presence of high levels of unsaturated fatty acids (oleic and linoleic) plus the high protein content in grain amaranth makes it a balanced grain.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results obtained in this study and comparison with other researchers' scientific findings, the following conclusions and recommendations were made:

Conclusions:

1. Growing of grain amaranth in Kwara state was successful with high yield of grains.
2. The grain amaranth in this study demonstrated the concentration of high valued and essential minerals especially zinc and iron that could stabilize immune function and potentially reduce complications from HIV/AIDS and anemia diseases respectively.

3. The contents of the magnesium and manganese in this study are also crucial to infants' growth and development.
4. The grain amaranth in this study was loaded with balanced nutrients. When included in diets at both household and village levels, it could provide high protein-energy weaning foods; and enhance the nutritional status of the populace toward food security and healthy living in Nigeria.

Recommendations:

1. Growing of grain amaranth should be encouraged at both household and community levels to enhance the nutritional status of the populace toward food security in Nigeria.
2. Inclusion of grain amaranth in diets should be adopted to produce high protein-energy weaning food for infants and balanced diets for adults for healthy living.
3. Amaranth Value Chain System that would include youths should be encouraged by Kwara State Government, Tertiary institutions, or Entrepreneurs in the growing, processing, value addition and marketing of grain amaranth. This would reduce youth unemployment and other associated socioeconomic problems in the Nigeria.
4. Further research studies need to be done in order to determine the status of growing and consumption of grain amaranth; and to promotion such in a value chain system.

REFERENCES

- Agong SG (2006). *Amaranthus caudatus* L. In: Brink, M. and Belay, G.(editors). Prota 1: Cereals and pulses. Prota, Wageningen, The Netherlands.
- AOAC, 2003. Official Methods of Analysis of the Association of Official Analytical Chemists, 17th edition. Association of Official Analytical Chemists, Arlington, Virginia.
- Bink M, Belay G (2006). Cereals and pulses. WUR, The Netherlands. Birch GG, Spencer M, Cameron AG (1980). Food science, (2nd ed., pp.29-37).Oxford, UK: Pergamon Press.
- Centeotl (2002). Amaranth: Ancient food of the gods for the people of today. Nutritional value. [Online]. Available at: <http://prodigyweb.net.mx/centeotlac/eng/pages/valor.htm> (Accessed on 5/4/2006).
- Dhellot JR, Matouba MG, Maloumbi JM, Nzikou DG, Linder M, Desobry S, Parmentier M (2006). Extraction, chemical composition and nutritional characterization of vegetable oils: Case of *Amaranthus hybridus* (var 1 and 2) of Congo Brazzaville. Afr. J. Biotechnol. (5):1095-1101.
- FAO/WHO (2002). Thiamin, riboflavin, niacin, vitamin B6, pantothenic acid and biotin. In: *Human Vitamin and Mineral Requirements*, Report of a Joint FAO/WHO Expert Consultation, FAO, Rome,; **3**: 27-30.
- Gardner Amanda (2014). 18 Health Benefits Of Whole Grains [www. huffingtonpost.com](http://www.huffingtonpost.com)
Posted: 08/10/2014 12:22 pm EDT Updated: 08/13/2014 11:59 am EDT
- Home Remedies (2008). Herbal medicines and amaranth. Retrieved on March 28, 2012, from:[http://www.best-home-remedies.com/herbalmedicine/vegetables /amaranth.htm](http://www.best-home-remedies.com/herbalmedicine/vegetables/amaranth.htm).
- Martirosyan DM, Miroshnichenko LA, Kulakova SN, Pogojeva AV and VI Zoloedov (2007). Amaranth oil application for coronary heart disease and hypertension, *Lipids In Health and Disease*,; **6**:10-11.

Mburu MW, Gikonyo NK, Kenji GM and AM Mwasaru (2012). Nutritional and Functional properties of a Complementary Food Based on Kenyan Amaranth Grain (*Amaranthus cruentus*). African Journal of Food Agriculture, Nutrition and Development. ISSN 1684 5374. Volume 12 No. 2 April.

Mnkeni AP, Masika P, Maphaha M (2007). Nutritional quality of vegetable and seed from different accessions of Amaranthus in South Africa. Paper presented at the International Symposium on the Nutritional Value and Water Use of Indigenous Crops for Improved Livelihoods held on 19th and 20th September 2006 at the University of Pretoria in Pretoria, South Africa.

Stephen Kariuki, Daniel Sila, Glaston Kenji (2013). Nutritional Profile of Amaranth Grain Varieties Grown in Kenya. Food Science and Quality Management www.iiste.org ISSN 2224-6088 (Paper) ISSN 2225-0557 (Online) Vol.17

Tung A (2010). Amaranth: Food Production without Attention. Nourishing the Planet Project.