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Retention of B- Carotene, Iron and Zinc in Solar Dried Amaranth Leaves in Kajiado County, Kenya

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Abstract

Amaranth is one of the underutilized vegetable with high nutritive value. Availability of amaranth leaves is seasonal and therefore preservation for use in other seasons is necessary. Solar drying is one of the recommended methods for vegetable preservation. Minimal information exists on nutrient content of amaranth leaves grown in dry areas. There is also scarce information on the effect of solar drying on the β -carotene, iron and zinc in amaranth leaves. The amaranth leaves were obtained from Kajiado County, an arid area. The β -carotene in fresh and solar dried amaranth leaves were analyzed using UV-VIS Spectrophotometry, while iron and zinc using Atomic Absorption Spectrophotometry (AAS). Results show that, the nutrient content for β -carotene, iron and zinc in fresh amaranth leaves was 5.75 ± 0.04 SD, 8.47 ± 0.05 SD and 3.18 ± 0.04 SD mg/100 g, respectively. This changed to 4.46 ± 0.04 SD, 7.98 ± 0.02 SD and 3.03 ± 0.03 SD with solar drying. This indicates retention of 77.5%, 94.3%, and 95.4% for β -carotene, iron and zinc, respectively. There was no significant ($P > 0.05$) change in β -carotene, iron and zinc with solar drying. Solar drying also led to high concentration of nutrients per unit where the amount of β -carotene, iron and zinc in 100 grams of solar dried leaves was noted as 40.11 ± 3.21 SD, 71.85 ± 6.93 SD and 27.28 ± 1.43 SD mg/100 g, respectively. This study recommends the use of solar drying to preserve the amaranth leaves.

Keywords: *Amaranthus cruentus*; solar drying; β -carotene; iron; zinc

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1. Introduction

Vitamin A, iron and zinc are some of the main micronutrients of public health concern in the world [1]. To ensure food security and dietary diversification in ASAL areas, focus on use of underutilized and drought resistant crops is recommended [2]. A research by Takyi [3] recommends the use of the underutilized locally available food materials that are inexpensive and high in micronutrients. A study by [4] determined that leafy vegetables, domesticated or wild, contained higher levels of β - carotene, iron and zinc compared to the exotic varieties such as spinach, kale and cabbage [5]. Indigenous vegetables have been shown to have a relatively high nutritional value compared to the exotic vegetables [6].

Amaranth leaves do not differ significantly with other green vegetables in terms of appearance, texture and flavour except for nutritive value [5]. Additionally, amaranth leaves have been found to have low levels of tannin and phytates which lower the bio-availability of minerals unlike in other vegetables [7,5]. The main vegetable species of amaranth commonly used are the *Amaranthus cruentus*, *A. graecizans*, *A. caudatus*, *A. tricolor* and *A. hybridus*. *Amaranthus cruentus* is one of the main vegetable species of amaranth commonly used in East Africa and more so in Kenya [5]. A study by Schmidt [8], on thirteen vegetables indicated that *Amaranthus cruentus* is the highest yielding among the amaranth species with a production of 3,473 kg/ha. Amaranth leaves are nutrient dense in vitamin A, iron and zinc [9,5,10,11]. In addition, relative to other crops it has a very short maturity period of 45 -75 days [5].

Amaranth is also a drought resistant crop and can withstand harsh desert climatic conditions [12,10]. Research has shown that amaranth, which is cultivated can also grow spontaneously during rainy seasons and were previously regarded as weeds [5]. Despite the numerous benefits of amaranth, its utilization in Kenya is low [5]. This is mainly due to seasonal variation [5,13].

Green leaves are highly perishable and have a short life span after harvesting [14,15,16,17]. During the wet season, amaranth leaves which are either cultivated or grow naturally are abundant but without post-harvest preservation, the excess after consumption goes to waste. Solar drying has been documented as an appropriate method for preserving green leafy vegetables to ensure that the vegetables that are in plenty during the wet seasons are available in other seasons [15]. Though drying leads to loss of a proportion of the water soluble vitamins, fat soluble vitamins like β - carotene are fairly well-retained [7].

During the process of solar drying, the leaves are completely protected against rain, dust, insects and animals. It is deemed as an economically feasible method for preservation at a local level [18]. According to Kendall [19], solar drying is more preferred because drying time is shorter since the drying temperatures are higher.

The nutritional quality of minerals in foods depends on quantity as well as bioavailability [20]. The bioavailability of key minerals such as iron and zinc is known to be significantly affected by phytic acid and tannin content of foods. The content of these anti-nutrients are altered by various processing methods including solar drying [21]. Solar drying has been found to lower oxalic acid, phytates and polyphenols significantly [22].

2. Problem statement

Micronutrient deficiencies especially vitamin A, iron and zinc remains a big challenge in the world. Amaranth leaves are rich in these micronutrients and can be used to fill the gap. Fresh amaranth leaves are seasonally available. A recommendation by [23] suggests the need to explore appropriate ways that can be adopted by rural communities to preserve the leafy vegetables for use during dry seasons when production is low. Fresh amaranth can be dried and stored using appropriate technology to ensure availability throughout the year [15]. Additionally, children rarely consume them in fresh form and thus drying would enable them be incorporated in common meals. In addition, there are problems in commercialization of amaranth leaves, mainly because of insufficient data.

There exists information gaps on the nutrient content of vitamin A, iron and zinc of amaranth grown in dry areas as the amount of vitamin A, iron and zinc in crops is region specific [24]. Due to this analysis of amaranth produced in the study area was necessary. This study aimed to evaluate the nutrient content of fresh and dried amaranth leaves (*Amaranthus cruentus*) grown in dry areas. This study provides information on micronutrients in amaranth leaves produced in dry areas and the effect of solar drying on nutrient levels.

3. Materials and methods

3.1 Source of amaranth leaves

The amaranth leaves used in this study were obtained from Kajiado South Sub-County, in Kajiado County, Kenya. The County and the Sub-County were purposively selected as one of the ASAL in Kenya. The study area is justified as there are ongoing initiatives on promoting amaranth production by Ministry of Agriculture [25].

3.2 Sampling amaranth leaves

In this study, the amaranth cultivar used was *Amaranthus cruentus*. This cultivar was selected based on its high yield and agronomic desirability. To obtain the best quality end product, vegetables should be fresh, tender, mature and should be dried immediately after harvest [19].

Ten farms out of the 20 being supported by local NGOs to produce and market the amaranth leaves were randomly selected. The leaves were harvested at the 6th week after germination, in the morning, for optimal nutrients [26]. Figure 1 shows the process of preparing amaranth leaves for analysis.

Using the zigzag sampling method, samples were collected from five points in each of the ten farms. The samples were packaged in perforated bags, placed in a cool box and immediately transported to Kenya Industrial Research and Development Institute (KIRDI) for analysis.

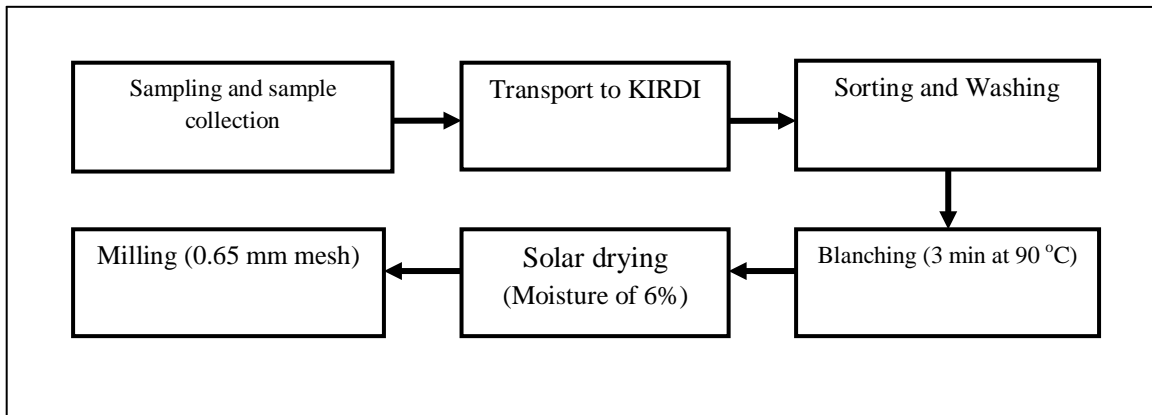


Figure 1. Amaranth leaves samples for nutrient analysis

3.3 Drying amaranth leaves

The leaves were sorted and washed under cold clean running water. This was followed by blanching in hot water for 3 minutes at 90 °C to inactivate enzymes which could contribute to low quality and nutrient losses [19]. Blanching is done before drying to preserve colour and flavour, minimize nutrient loss, stop decomposition, ensure even drying and extend storage life [19].

The leaves were then cooled by immersing in cold water for 30 seconds. They were strained to remove excess water. The leaves were then spaced on the drying trays without overlapping [19]. Finally, the trays were placed into the solar boxes for drying. Drying was done until a moisture content of 6% was attained. Milling was done using 0.65 mm mesh. They were then packaged in sealed polythene bags to prevent moisture absorption and transported to the laboratory for analysis. Sampling was repeated after 3 months to obtain different samples for analysis.

3.4 Nutrient content analysis

β - carotene analysis

The content of β - carotene was established using UV–VIS Spectrophotometry method. To extract β - carotene, 50 mls of acetone–hexane mixture containing 0.1% BHT was added to 5 g sample and the mixture shaken for 10 minutes, centrifuged and decanted to a separating funnel. The supernatant was saponified by adding 25 mls of 0.5M methanolic potassium hydroxide. It was then shaken and allowed to settle for 30 minutes, then washed with 100 mls portions of distilled water while discarding the aqueous layer continuously. The extract was then dried by filtering over anhydrous sodium sulphate. The filtrate was concentrated in a rotary evaporator at 45°C and reconstituted in methanol to 50 mls.

Different concentrations of standard solution were prepared using 95% UV β - carotene Type 1 (Sigma Chemicals). A stock solution of (100 $\mu\text{g/ml}$) was made by dissolving 0.01 g of β - carotene standard into 10 mls hexane, which was then increased to 100 mls. The working standard solution was used to prepare standard solutions of various concentrations (1 – 12 $\mu\text{g/ml}$). The absorbance (A) of each concentration was measured using the UV–Vis Spectroscopy as recommended by Gupta *et al.* [27].

Analysis of iron and zinc

Iron and zinc was done using AAS [27]. For the determination of minerals, 1 gram of food sample was weighed into a digestion tube. Concentrated nitric acid (5 mls) was added to the sample and heated. Hydrogen peroxide (30%) was added to the digestion mixture until it became clear. The clear solution was then topped up to 50mls with a volumetric flask.

A working solution of 10 mls of 1000 ppm (stock solution) was put into 100 mls flask and topped up to 100 mls mark with distilled water. A calibration standard for iron was prepared by adding 0, 2, 4, 6 and 8 mls of the working standard solution into 100mls volumetric flask and topping up to 100 mls using distilled water. Both the samples and the standards were aspirated for analysis in atomic absorption spectrophotometry [27]. A plot of calibration graph of concentration (ppm) against the absorbance was made. From the calibration curve the absorbancies of the samples were extrapolated to determine the content of iron in the samples. This procedure was repeated for zinc analysis.

3.5 Research permit and ethical considerations

The research permit was sought from the National Council for Science and Technology. Ethical clearance was obtained from Kenya Medical Research Institute Ethical Review Committee.

4 Results and discussion

4.1 Nutrient content of amaranth leaves

The results revealed that the moisture content of fresh amaranth leaves was found to be 85.3 %. This finding is consistent with other studies which determined the water content in amaranth leaves which ranged between 80 - 90% [23]. The amount of β -carotene, iron and zinc in fresh amaranth leaves was 5.75 ± 0.04 SD, 8.47 ± 0.05 SD and 3.18 ± 0.04 SD mg/100 g, respectively (Table 1).

Table 1 Content of nutrients in amaranth leaves (mg/100g)

(n=3)	Fresh	Solar dried	Nutrient retention
β -carotene	5.75 ± 0.04	4.46 ± 0.04	77.5%
Iron	8.47 ± 0.05	7.98 ± 0.02	94.3%
Zinc	3.18 ± 0.04	3.03 ± 0.03	95.4%

The content of β - carotene for fresh leaves from a study by Gupta and his colleagues [27], was 5.25 mg while from a study by Singh *et al.* [28], indicated (13.46 mg/100 g). The iron content from a study by Singh *et al.* [28], was 3.35 mg/100g. A study by Mosha [29], shows zinc content in amaranth as 1.7 mg/100g. There was no significant $P > 0.05$ change in β -carotene, iron and zinc with solar drying.

Gupta and his colleagues [23], showed the retention for β – carotene after solar drying to be above 70%. This is in agreement with results of Premavalli and his colleagues [30], which showed that solar drying of amaranth leaves led to retention of β - carotene by 67.6%. In addition a study conducted in Tanzania showed that solar-dried vegetables led to retention of $>66\%$ of β – carotene [31]. According to Lakshmi and Vimala [32], drying of green leafy vegetables can retain substantial amounts of β - carotene, iron and zinc.

The retention of iron after solar drying was 94.3% while for zinc was 95.4%. This retention is an indication that solar drying of amaranth leaves does not greatly affect micronutrient content for iron and zinc. This is in agreement with analysis of chemical composition by Gupta and Lakisami [14], which showed no significant losses of iron and zinc contents with solar drying of green leafy vegetables. Other studies reported minimal iron and zinc losses associated with drying of vegetables [16,33,34].

Though drying leads to loss of a proportion of the water soluble vitamins, β – carotene which is fat soluble, is fairly well-retained [17,19]. Solar drying of vegetables has been found to have a higher retention of micronutrients than sun drying [35,18,36,37]. Through solar drying, more β - carotene is maintained than in sun drying [35]. Various studies have concluded that solar drying achieves a β -carotene retention ranging from 60—66% [14,31,30].

4.2 Content of nutrients in solar dried amaranth leaves after concentration

Results indicated that the content of β -carotene, iron and zinc was 40.11 ± 3.21 SD, 71.85 ± 6.93 SD and 27.28 ± 1.43 SD mg/100 g, respectively. The content of β -carotene, iron and zinc for solar dried amaranth leaves is shown in Table 2.

Table 2 Content of nutrients in dried amaranth leaves due to concentration

(n=3)	Dried amaranth leaves (mg/100g)
β -carotene	40.11 ± 3.21
Iron	71.85 ± 3.93
Zinc	27.28 ± 1.43

This is an indication that solar drying led to concentration of nutrients after dehydration. This is similar with studies by Gupta and his colleagues [23] and Makobo and his colleagues [17] which indicate that dehydrating vegetables provides a concentrated source of micronutrients. The β - carotene content in the DAL determined in the current study are comparable with those reported in other studies. The levels of β - carotene in dried

amaranth leaves were found to be 19.0 to 53.07 mg/100 g [22]. A study by by Mulokozi and his colleagues [38], indicated 44.9 mg/100g. However, these results were higher than those of a study by Mosha and his colleagues [36], which was 26.79 mg/100g.

The amount of iron (71.85 ± 6.93 SD) found in this study was similar to values derived from analysis of dried amaranth leaves by Yadav and Sehgal [22], which showed 60.63 mg/100g. The amount of zinc in the dried amaranth leaves (27.28 ± 1.43 SD mg) was slightly higher than results by Yadav and Sehgal [22], which found zinc content of 11.70 mg/100 g.

Drying has been found to have no significant effect on iron content in amaranth [22] and zinc content [17,11]. DAL products are well- accepted just like those made from dried spinach [39]. A study by Singh and his colleagues [28], which used 5% dried amaranth leaf powder showed tremendous increase in vitamin A, iron and zinc among children. This is an indication that relatively small amounts of dried amaranth leaves incorporated in fermented maize flour can meet the RDAs for vitamin A, iron and zinc.

5. Conclusion and recommendations

In conclusion, solar drying of amaranth leaves is an effective method of food preservation and can be used to close the seasonal gaps. It is associated with minimal loss of nutrients. Drying of green leafy vegetable leads to concentration of nutrients per unit. This is an indication that use of a relatively small amount of dried amaranth leaves can significantly raise the content of β -carotene, iron and zinc in the diet and enables the population to meet the RDAs for these micronutrients. This study recommends the use of solar drying as a viable strategy to address the seasonality gaps while ensuring retention of these essential nutrients.

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References

- [1] L. E. Caulfield., S. A. Richard., J. A. Rivera., P. Musgrove. and R. E. Black. (2006). *Stunting, wasting, and micronutrient deficiency disorders*. Disease control priorities in developing countries pp. 551-567.
- [2] M. Esilaba., D. Okoti., G. Nyariki., J Keya., J. Miriti., Kigomo. and G. Olukoye. (2011). *The Desert Margins Programme Approaches in Upscaling Best Technologies in Arid and Semi-arid Lands in Kenya. Innovations as Key to the Green Revolution in Africa* (pp. 1177-1191). Dordrecht: Springer Netherlands.
- [3] E.Takyi. "Children's Consumption of Dark Green Leafy Vegetables with added Fat Enhances Serum Retinol." *Journal of Nutrition*, vol. 120, pp 1549-1554, 1999.

- [4] F. Orech., D. Christensen., T. Larsen., H. Friis., J. Aagaard-Hansen. and B. Estambale. "Mineral Content of Traditional Leafy Vegetables from Western Kenya." *International Journal of Food Sciences and Nutrition*, vol 58, pp 595-602, 2007.
- [5] D. Mwangi. (2003). *Introduction to Amaranth*. 2nd Edition Joypet Services and Printers Nairobi - Kenya. Pg 51-56.
- [6] J. Chweya and P. Eyzaguirre. (2008). *The Biodiversity of Traditional Leafy Vegetables*. Rome, Italy: International Plant Genetic Resources Institute.
- [7] U. Singh., V. Sagar., T. Behera. and S. Kumar. "Effect of Drying Conditions on the Quality of Dehydrated Selected Leafy Vegetables." Division of Post-harvest Technology, Indian Agricultural Research Institute, New Delhi-110 012, India. *Journal of Food Science and Technology*, Vol 43(6), pp 579-582, 2006.
- [8] D. Schmidt. "Comparative Yields and Composition of Eight Tropical Leafy Vegetables Grown at Two Soil Fertility Levels." *Agronomy Journal* . Vol. 63(4), pp. 546-550, 2011.
- [9] O. Funke. (2011). *Evaluation of Nutrient Contents of Amaranth Leaves Prepared Using Different Cooking Methods*. Food and Nutrition Sciences, 02, 249-252.
- [10] UNICEF and GOK. (1999). *National Micronutrient Survey*. UNICEF House, NY, NY. Website www.unicef.org. Pg 120-128.
- [11] S. Yadav. and S. Sehgal. (1995). *Effect of Home Processing on Total and Extractable Calcium and Zinc Content of Spinach (Spinach Oleracia) and Amaranth (Amaranthus Tricolor) Leaves*. Plant Foods for Human Nutrition, 48, 65-72.
- [12] G. Grubben. and O. Denton. (2004). *Plant Resources of Tropical Africa 2 Vegetables*. PROTA Foundation. Wagenininn, Netherlands. Pg 68.
- [13] S. Smitasiri., G. Attig. A., Valyasevi. and K. Tontisirin. (1993). *Social Marketing Vitamin A-Rich Foods in Thailand: A Model Nutrition Communication for Behaviour Change Process*. Salaya, Thailand, Mahidol University Institute of Nutrition; Bangkok, UNICEF East Asia and Pacific Regional Office.
- [14] S. Gupta. and A. Lakshmi. "Nutritional and sensory quality of micronutrient-rich traditional products incorporated with green leafy vegetables." *International Food Research Journal*. Vol 18(2), pp 456-58, 2011.
- [15] M. Masarirambi., V. Mavuso., V. Songwe., T. Nkambule. and N. Mhazo. "Indigenous Post-Harvest Handling and Processing of Traditional Vegetables in Swaziland: A Review". *African Journal of Agricultural Research*. Vol 5 (24), pp 3333-3341, Dec. 2010.
- [16] P. Negi. and S. Roy. (2001). *Effect of Drying Conditions on Quality of Green Leaves During Long Term Storage*. Food Research International, 34, 283-287.
- [17] N. Makobo., M. Shoko. and, T. Mtaita. "Nutrient Content of Amaranth (Amaranthus Cruentus) under Different processing and preservation stages." *World Journal of Agricultural Science*. Idosi Publications, vol 6 (6), pp 639-643, 2010.
- [18] A. Esper. and W. Mühlbauer. (1998). *Solar drying - An Effective Means of Food Preservation Renewable Energy*. September 15 (4). 95-100.

- [19] P. Kendall. (2003). *Drying Vegetables. Food and Nutrition Series. Colorado State University Cooperative Extension.* Fort Collins. USA.
- [20] F. Jalal., M. Nesheim., Z. Agus., Z. Sanjur. and J. Habicht. "Serum Concentration in Children are Affected by Food Sources of Beta Carotene, Fat Intake and Anthelmintic Drug Treatment." *American Journal of Clinical Nutrition*, vol 68, pp 623-629, 1998.
- [21] S. Jackson., M. Knize. and J. Morgan. (1999). *The Impact of Food Processing on the Nutritional Quality of Vitamins and Minerals.* Advance in Experimental Medicine and Biology. Kluwer Academic / Plenum Publishers.
- [22] S. Yadav. and S. Sehgal. (2002). *Effect of Domestic Processing and Cooking Methods on Total, Hcl Extractable Iron and in Vitro Availability of Iron in Spinach and Amaranth Leaves Nutrition and Health.* Department of Foods and Nutrition. CCS Haryana Agricultural University, Hisar, 125004, INDE 2002, Vol. 16, pp. 113.
- [23] S. Gupta., B. Gowri., A. Lakshmi. and J. Prakash. "Retention of Nutrients in Green Leafy Vegetables on Dehydration." *Journal of Food Science and Technology.* 2011.
- [24] G. Keding., B. L. Maass. D. Virchow. J. Msuya. and M. Krawinkel. (2008). *Consumption of Traditional and Exotic Vegetables and their Perceived and Real Contribution to Nutritional Health in Tanzania.* Arusha, Tanzania, Seminar presented at International Symposium Underutilized Plant Species for Food, Nutrition, Income and Sustainable Development.
- [25] ALRMP. (2008). *Arid Lands and Resource Management Project.* Monthly Bulletin Kajiado District.
- [26] F. Showemimo. and J. Olarewaju. "Yield and Yield Component Relationships in *Amaranthus cruentus* L." *Tropical Agriculture journal*, vol 81(3), pp 175-178, 2004.
- [27] S. Gupta., A. Jyothilakshmi., M. Manjunath. and J. Prakash. (2005). Analysis of nutrient and antinutrient content of underutilized green leafy vegetables. *Food Science and Technology.*
- [28] S. Singh. D. Punia. and N. Khetarpaul. "Nutrient Composition of Products Prepared by Incorporating Amaranth (*Amaranthus tricolor*) Leaf Powder into Commonly Consumed Products." *Journal of Nutrition and Food Science.* Vol 39(3). Pp 218 – 226, 2009.
- [29] T. Mosha., H. Gaga., R. Pace., H. Laswai. and K. Mtebe. (1995). Effect of Blanching on the Content of Antinutritional Factors in Selected Vegetables. *Plant Foods for Human Nutrition (Dordrecht, Netherlands)*, 47(3), 361-367.
- [30] K. Premavalli., T. Majumdar. and C. Madhura. "Processing Effect on Colour and Vitamins of Green Leafy Vegetables. Defence Food Research Laboratory." *Journal of Food Science and Technology*, vol 38(1), Pp 79-81, 2001.
- [31] G. Mulokozi. and U. Svanberg. "Effect of Traditional Open Sun-Drying and Solar Cabinet Drying on Carotene Content and Vitamin A Activity of Green Leafy Vegetables." *Journal Plant Foods for Human Nutrition*, vol 58 (3), 1-15, 2003.
- [32] B. Lakshmi. and V. Vimala. "Nutritive Value of Dehydrated Green Leafy Vegetable Powders. Post-Graduate and Research Center, Faculty of Home Science, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad-500 030" *Journal of food science and technology*, vol 37, pp 465-471, 2000.

- [33] P. Negi. and S. Roy. (2000). Effect of Blanching and Drying Methods on β -Carotene, Ascorbic acid and Chlorophyll Retention of Leafy Vegetables. *Lebensmittel-Wissenschaft und-Technologie*, 33, 295-298.
- [34] O. Onayemi. and G. Badifu. (1987). Effect of Blanching and Drying Methods on the Nutritional and Sensory Quality of Leafy Vegetables . *Plant Foods for Human Nutrition*, 37 (4), 291-298.
- [35] H. Nyambaka. and J. Riley. (2001). *Degradation of Pro-Vitamin A Active Compounds of All Trans – Beta Carotene in Dehydrated Green Green Leafy Vegetables*. Bull. Chem. Soc. Ethiopia 15 (1) 57-64.
- [36] T. Moshia. R. Pace. S. Adeyeye., H Laswai. and K. Mtebe. (1997). *Effect of Traditional*
- [37] *Processing Practices on the Content of Total Carotenoid, Beta-Carotene, Alpha-Carotene and Vitamin A Activity of Selected Tanzanian Vegetables*. Plant Foods for Human Nutrition (Dordrecht, Netherlands), 50 (3), 189-201.
- [38] F. Clydesdale. (1991). *The Effect of Post-Harvest Treatment and Chemical Interactions on the Bio-Availability of Ascorbic Acid, Thiamine, Vitamin A Carotenoids, and Minerals*. Critical Reviews in Food Science and Nutrition 30 (6) 599 -639.
- [39] G. Mulokozi., E. Hedren. and U. Svanberg. “In Vitro Accessibility and Intake of Beta- carotene from Cooked Green Leafy Vegetables and their Estimated Contribution to Vitamin A Requirements.” *Journal of Plant Foods for Human Nutrition*, vol 59 (1), pp 2-9, 2004.
- [40] R. Borneo. and A. Aguirre. (2008). *Chemical Composition, Cooking Quality and Consumer Acceptance of Pasta Made with Dried Amaranth Leaves Flour*. Lebensmittel – Wissenschaft Technologies. Volume 41. Germany. Pages 1748- 1751.