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Copper and Ascorbic Acid Content of Cooked African Indigenous Vegetables

Florence Habwe[a*], Mary K. Walingo[a], Mary O. Abukutsa-Onyango[b]

[a]Maseno Unviersity, School of Public Health and Community Development, Kenya
[b]Jomo Kenyatta University of Agriculture and Technology, Horticulture, Kenya

Introduction

Malnutrition is common among women of childbearing age, it is made worse by micronutrient deficiency (Farm Africa, 2006). African Indigenous Vegetables (AIVs) are important for dietary diversification; they are a rich source of many micronutrients needed for good health (Oniang'o *et, al* 2005). They are fast becoming the vegetable of choice especially in the segments of the society where consumption has been minimal (Shiundu and Oniang'o, 2007). The increased need to consume AIVs is due to availability of these vegetables to the lower end of the market consumers whose majority are the poor (Shiundu and Oniang'o, 2007). This shows the urgency of the need for information and knowledge on AIV processing and preparation alongside their nutrient contents after cooking. A survey by Waudo *et al*., 2005 and 2007 revealed low AIV consumption among women, children and in the urban and Peri-urban populations of Lake Victoria region due to lack of knowledge on preparation and cooking of AIVs. The main objective of this research was to formulate recipes of African indigenous vegetables using traditional salt (lye) and evaluate their copper and ascorbic acid contents. Four priority AIVs including: African nightshade (*Solanum scabrum*), Vegetable Amaranth (*Amaranthus blitum*), Slenderleaf (*Crotalaria ochroleuca*) and Cowpea (*Vigna unguiculata*) were randomly selected to formulate six more vegetable combinations before cooking where each vegetable had a probability of being combined with another.

Materials and Methods

Source of Experimental AIVs

Experimental research involved four randomly sellected African indigenous vegetables commonly found in East Africa. They included: African nightshade (*Solanum scabrum)*, vegetable amaranth (*Amaranthus blitum)*, slender-leaf (*Crotalaria ochroleuca)*, and Cowpea (*Vigna unguiculata)*. They were planted and all agronomic practices done to ensure optimum growing conditions. Harvesting by uprooting was done at four weeks after seedling emergency, they were then destalked to separate vegetable leaves from stems.

Cooking of AIVs

Vegetables were washed to remove dirt and shredded in preparation for cooking with and without traditional salt (lye) The traditional salt was prepared from dried pods of green beans after removing the mature seeds, the dry pods were completely burnt over a hot dry pan and the ash collected. The ash was put in a container whose bottom had small holes and water poured in it to pass through the ash into another container underneath. This residue is the traditional salt or lye. Four single and six vegetable combinations were boiled for ten minutes with and without lye, then fried for five minutes using onions and tomatoes, giving rise to twenty vegetable recipes.

Sample Preparation and Nutrient Analysis

After cooking, AIV samples were prepared for nutrient analysis as described by (Apha, 1985). Atomic Absorption Spectroscopy (AAS) was used to determine the copper content while titration method was used to analyze ascorbic acid content of selected AIV samples as described by (Gerge, 1984). Analysis was done on raw, boiled, and fired AIVs.

Data Analysis

Data obtained were analyzed using ANOVA, descriptive and inferential statistics; they were subjected to independent and paired sample t-test to determine whether the treatments' effects were significant at 5% level of significance.

Results and Discussion

Copper Content

Table 1: Copper Content (mg/g) of Selected AIVs under Different Treatments

AIVs	Raw AIVs	Boiled With Lye	BOILED Without Lye	FRIED With Lye	FRIED Without Lye	Average
Nightshade	0.44	0.52	0.34	0.98	1.52	0.76ab
Cowpea	0.16	0.16	0.6	0.1	6.32	1.468ab
Slenderleaf	0.28	0.32	0.12	0.42	0.1	0.248b
Amaranth	0.18	0.46	0.18	3.48	0.06	0.872ab
Nightshade&Amaranth	0.42	0.24	0.4	0.74	0.18	0.396b
Nightshade&Slenderleaf	0.3	0.2	0.34	0.08	0.36	0.256b
Nightshade & Cowpea	0.26	0.46	1.36	1.18	0.08	0.668ab
Amaranth & Slenderleaf	0.34	0.36	1.66	4.56	4.56	2.296a
Amaranth & Cowpea	0.16	0.46	0.2	0.7	0.6	0.424b
Slenderleaf & Cowpea	0.28	0.28	0.18	0.14	0.1	0.196b
Average	0.282	0.346	0.538	1.238	1.388	
Significance Level						0.05
LSD						1.68
Interaction	**Cooking Method*Lye**					**Ns**
	Cooking Method*AIV					**ns**

NB. Traditional Salt (Lye) = **1.6mg/g**

Results indicate no significant interactions between cooking method and AIV. A combination of amaranth and slenderleaf recorded significantly higher copper solubility (Table 1). Cooking increased copper content of African indigenous vegetables but whether the vegetables are cooked as single vegetables or as a combination of two vegetables, did not have an effect on their copper content. For example, a combination of amaranth and slenderleaf boiled without lye, fried with lye, and fried without lye had the highest copper contents of 1.66mg/g, 4.56mg/g, and 4.56mg/g respectively compared to amaranth alone (3.48mg/g), and slenderleaf alone (0.42mg/g) (Table 1 and Figure 1). Therefore combining vegetables during preparation have different effects on different vegetables in terms of their copper content. This could be due to different nutrient-nutrient interactions between different vegetables (Figure 1).

RDA for copper is 2-3mg (FAO, 2003), table 1, indicates that all other fried recipes can only supply the RDA if more than a gram is consumed, apart from nightshade fried without lye (1.52mg/g), cowpea fried without lye (6.23mg/g), amaranth fried with lye (3.48mg/g), and amaranth with slenderleaf fried with and without lye (4.56mg/g each) which can supply the RDA when only one gram is consumed.

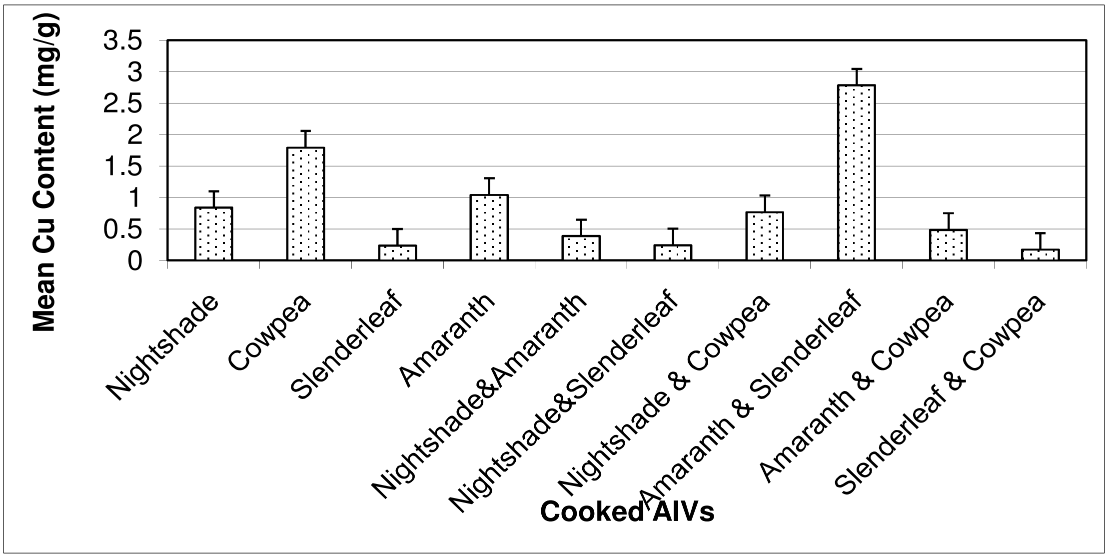

Fig.1. Mean Copper Content (mg/g) in different Cooked AIVs and AIV combinations

Recipes prepared without lye had higher mean copper content for fried compared to boiled ones, therefore frying increased copper content of AIVs. Paired sample t-test was applied and results indicated that fried AIVs had significantly higher mean copper content compared to boiled ones ($P<0.05$). There were insignificant differences in the mean copper content between recipes fried with traditional salt and those fried without traditional salt ($P>0.05$). Raw AIVs had the least copper content compared to boiled and fried ones. On the other hand, fried AIVs had higher copper content compared to the boiled ones.

Ascorbic Acid (Vit C) Content

The raw, boiled and fried vegetables were determined for Vitamin C content using the vitamin C screening method as described in the methodology above and expressed in mg/g. Table 2, show the effect of different cooking methods and the use of lye on Vitamin C content of AIVs.

Table. 2. Vitamin C Content (mg/g) of Selected AIVs under Different Treatments

AIVs	Raw AIVs	Boiled With Lye	BOILED Without Lye	FRIED With Lye	FRIED Without Lye	Average
Nightshade	5.7	5.7	6	6.1	6.9	6.08[a]
Cowpea	5.7	4.3	3.6	5.7	7.1	5.28[a]
Slenderleaf	6.4	5.7	6.4	5	6.2	5.94[a]
Amaranth	6	5.7	6.4	5.7	5	5.76[a]
Nightshade & amaranth	6	5	5.7	5	6.4	5.62[a]
Nightshade&Slenderleaf	3.6	6.4	6.8	7.9	5.7	6.08[a]
Nightshade &Cowpea	6.7	6	5.7	5.7	5.7	5.96[a]
Amaranth & Slenderleaf	5.7	5.7	7.1	5.7	5.7	5.98[a]
Amaranth & Cowpea	5.7	5	5.6	6.4	6.3	5.8[a]
Slenderleaf & Cowpea	5.3	5	4.3	6.4	5.7	5.34[a]
Average	5.68	5.45	5.76	5.96	6.07	
Significance Level						0.05
LSD						0.96
Interaction	**Cooking Method*Lye**					**ns**
	Cooking Method*AIV					**ns**

NB. Traditional Salt (Lye) = **0mg/g**

Table 2 indicates no significant interactions between cooking method and AIVs, there were also non significant differences between all the AIVs. A combination of nightshade and slenderleaf fried with lye had the highest Vitamin C content (7.9mg/g), even higher than in nightshade alone (5.7mg/g - 6.9mg/g) and slenderleaf (5mg/g – 6.4mg/g) whether raw or cooked. A combination of raw nightshade and slenderleaf had the least vitamin C content (3.6mg/g) compared to raw or cooked nightshade (5.7mg/g – 6.9mg/g) and slenderleaf (5mg/g – 6.4mg/g) (Table 2). Nutrient-nutrient interaction might have occurred between raw nightshade and slenderleaf, which resulted, to reduction in vitamin C content of this combination. Boiling with lye reduced vitamin C content of other AIVs except nightshade, nightshade with slenderleaf, and amaranth with slenderleaf. Combining vegetables during preparation had different effects on vitamin C content of different vegetables, this could be due to nutrient-nutrient interactions between different vegetables; some AIVs had higher content as combinations than as single vegetables and vice versa.

Fried AIVs had higher vitamin C content compared to raw and boiled ones. Figure 3 clearly shows the general effect of cooking and use of lye on vitamin C content of AIVs. Lye slightly reduced vitamin C content of AIVs compared to the raw ones. The reductions in vitamin C content after boiling were minimal and this is due to the less boiling time of only 10 minutes, moderate cooking temperature and putting of vegetables in already boiling water rather than boiling water together with the vegetables. Use of traditional salt is seen to reduce vitamin C content of vegetables, frying on the other hand increased vitamin C content of the same vegetables (Figure 3).

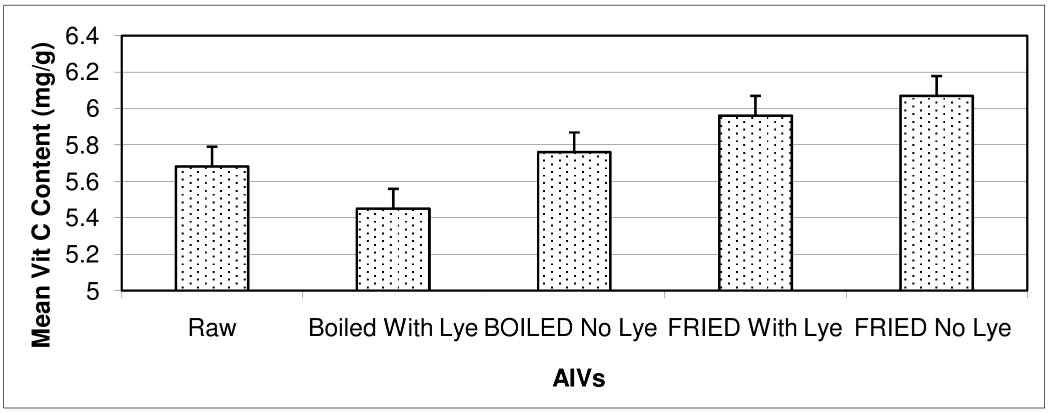

Fig. 3. General Effect of Cooking on Vitamin C Content of AIVs

Fried AIVs recorded higher mean for vitamin C content (without lye = 608.1 $\pm$ 63.6, with lye = 596.8 $\pm$ 82.4) compared to the boiled recipes (without lye = 577.1 $\pm$ 110.8, with lye = 545.7 $\pm$ 62.4), this means frying increased vitamin C content of recipes. However, in order to find out if the mean difference was significant for both fried and boiled with or without lye, independent sample t-test was applied and the results indicated insignificant mean difference between boiled and fried AIVs (P>0.05). Although there were very minimal increase in Vitamin C content of the fried AIVs, this minimal increase could be attributed to the use of onions and tomatoes, which are known to contain (11mg/100g and 10 mg/100g) of vitamin C respectively (Sehmi, 1993); and the minimum cooking time and temperature. According to Gahler *et, al.,* (2003), the best way of deriving benefits of vitamin C is eating fresh vegetables or with a minimum of cooking. This is true in relation to the study results which indicate minimum loss of Vitamin C content of AIVs after ten minutes of cooking under low temperature.

Conclusions and outlook

The cooked AIVs had adequate copper and vitamin C to supply the consumers with the recommended daily allowances especially for iron. The cooking method of frying should be used during AIV preparation in order to help minimize nutrient loss during preparation. However, more varied preparation methods should be employed. Other vitamins and minerals should be analyzed as well to provide more information on the nutrient content of cooked AIVs as this is paramount to improving community's nutrition status. Nutrient bioavailability in the developed recipes should be determined if improving the nutrition status of the community is to be realized. More and varied preservation and processing research should be carried out to increase and determine AIVs' shelf life.

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