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Full Length Research Paper

Iron content of the formulated East African indigenous vegetable recipes

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Nutritional iron deficiency is the common cause of anaemia in developing world. However, Africa is endowed with African indigenous vegetables (AIVs) rich in micronutrients. Surveys within East Africa relate low AIV consumption to limited information on recipe preparation. The aim of this research is to determine iron content of various formulated indigenous vegetable recipes. Experimental research involved four randomly selected AIVs; African Nightshade (*Solanum scabrum)*, Vegetable Amaranth (*Amaranthus blitum*), Slenderleaf (C*rotalaria ochroleuca*) and Cowpea (*Vigna unguiculata*). Four single and six vegetable combinations were boiled for ten minutes with and without traditional salt, then fried for five minutes using onions and tomatoes, giving rise to twenty recipes. Iron content was evaluated using Atomic Absorption Spectroscopy. Iron content of raw indigenous vegetables was significantly ($P < 0.05$) lower than boiled and fried AIVs. Fried AIVs had significantly ($P < 0.05$) higher iron content compared to the boiled AIVs. Mean iron content of AIVs fried with lye was insignificantly ($P > 0.05$) lower compared to those fried without lye. Fried AIVs should be recommended in areas with high dietary iron deficiency; this could help alleviate anaemia.

Key words: Iron content, recipes, lye, African indigenous vegetables.

INTRODUCTION

Indigenous vegetables are vegetable species native to or originating from a particular region or environment, are acceptable and used in the diet of rural and urban people (Maundu, 1997; FAO, 1988). African indigenous vegetables can play a significant role in addressing three major factors of low income, malnutrition and loss of bio-diversity. The diversity of these African indigenous vegetables forms the basis of food and nutrient diversity (FAO, 2003). These vegetables are still valuable sources of nutrients thus contribute substantially to vitamin and mineral intake (Waudo et al., 2007; Farm Africa, 2006; Abukutsa-Onyango, 2003). They contribute essential components of the meal by contributing micronutrients like iron which are usually in short supply in daily diets, especially where animal protein is unaffordable (Mosha and Gaga, 1999). Some of these vegetables are gathered when in season, grown in home gardens or intercropped with staples; and eventually find their way to the urban markets (Mnzava, 1995).

AIVs can be used as cash crops in peri-urban systems, source of vegetables for daily sustenance in home gardens, source of new crops and as source of variation for diversification of production systems and diet. While most AIVs are nutritious if well cooked, a survey carried out by Waudo et al. (2005) in wetlands of Lake Victoria

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Abbreviations: AIVs, African Indigenous Vegetables; **AVRDC,** Asian Vegetables Research and Development Center; **AAS**, Atomic Absorption Spectroscopy; **ACC**, Administrative Committee on Coordination; **FORMAT**, Forum for Organic Resource Management and Agricultural Technologies; **IVs**, Indigenous Vegetables; **ICRAF**, International Center for Research in Agroforestry, **IPGRI**, International Plant Genetic Resources Institute, **IDA**, Iron Deficiency Anaemia; **KENRIK**, Kenya Resource Center for Indigenous Knowledge; **NEVEPA**, Network Vegetable Production in Africa; **NMK**, National Museums of Kenya; **SCN**, Sub-Committee on Nutrition; **UNICEF**, United Nations Children's Fund; **VICRES**, Lake Victoria Research Initiative; **WAC**, World Agroforestry Center; **WHO**, World Health Organization; **WVC**, World Vegetable Center.

region and that of Waudo et al. (2007) in urban and peri-urban settings of Nairobi Kenya, shows low intakes of AIVs by women and children due to lack of knowledge on preparation and cooking procedures. The later survey shows that respondents used AIV cooking procedures that could lead to a decrease of the nutritive value of cooked vegetables. It is therefore no wonder that micro-nutrient deficiency mainly vitamins and minerals particularly iron is a serious problem in sub-Saharan Africa affecting about a third of the population with far reaching effects (UNICEF, 2004).

Survey results by Waudo et al. (2007) indicate the need to discourage chopping vegetables before washing, repeated boiling and adding of sodium bicarbonate to vegetables while cooking. However, there has been very little information on recipes and their nutrient content which has been in high demand (Shiundu and Oniang'o, 2007). This shows the urgency need of information and knowledge on AIV processing and preparation alongside their nutrient content after cooking; as agreed by Padma, 2005, who stated that it is not enough to develop recipes but their nutrient content is important in the effort of improving nutrition security. The objective of this study was to develop East African indigenous vegetable recipes and evaluate their iron content.

MATERIALS AND METHODS

Study site

The study was carried out at Maseno University, Kenya. Long-term average rainfall in Maseno is 2074 mm per annum and its distribution is bimodal with peaks in March/April and September /October (Oseko, 2007). Soils are mainly dominated by vertisols, with a fairly acidic pH in water of 4.5 to 6.5 (Otieno et al., 1993; GOK, 2002; and Oseko, 2007). The soils are also deep, very deficient in potassium (P) and Nitrogen (N) and have moderate potassium (P) fixation (FAO,1997, cited by Oseko, 2007). Mean annual day temperature is 20°C with the average maximum daily temperature not exceeding 31°C and the average minimum night temperature above 15°C (Otieno et al., 1993; GOK, 2002; Oseko, 2007).

Source of East African indigenous vegetables

African indigenous vegetables used in the experiment were planted at the Maseno University Botanic garden. Land was prepared by ploughing and harrowing to a fine tilth. A plots of 5 × 5 m were demarcated and poultry manure was mixed with the soil in the demarcated plot at a rate of 5 tons per ha. Seeds of each selected AIV were mixed with the soil at a rate of 1:10 and drilled in the respective plots at a spacing of 30 cm. After two weeks, thinning was done to leave an inter-raw spacing of 15 cm for all. All other agronomic practices were done to ensure optimum growing conditions. Harvesting was done at four weeks after seedling emergency. This resulted to AIVs with similar harvest age and environmental exposure.

Formulation of East African indigenous vegetable recipes

After harvesting the AIVs, immediately destalking was done to separate vegetable leaves from the stems in order to minimize nutrient loss. Required amounts of AIVs were then weighed and various vegetable categories of single vegetables and vegetable combinations were made. This resulted into four single vegetables and 6 vegetable combinations that were washed to remove dirt and then boiled with and without traditional salt for ten minutes over moderate heat at 40°C. After boiling, vegetables were put aside and vegetable oil was put on a pan on fire to heat, diced onions were fried till golden brown, chopped tomatoes added and cooked till soft while stirring to improve taste and aroma. The boiled vegetables were then added, stirred and common salt was put to taste. This was simmered for two minutes, removed from fire and served.

The traditional salt (lye) was prepared by drying the pods of green beans after removing the mature seeds, the dry pods were then burnt over a hot dry pan and the ash collected after complete burning. 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. The residue is what is known as traditional salt or lye.

Sample preparation for elemental analysis

After cooking, samples were cooled and immediately kept in the fridge at 4°C to prevent distortion of the cooking ingredients. Samples were oven-dried at 60°C for 12 h then crushed into fine powder using a mill (QCG System LLC Model 4E). The powdered samples were sieved through 125 µm apertures BS 410. 0.5 g of each sample was weighed and placed in a kjeldahl tube in 20 mls of aqua regia acid (5 ml HCl + 5 ml Nitric acid) (Apha, 1985). The tubes were then heated to boiling for 2 h at 96°C until the resulting solution was clear and the heating was continued for 30 more minutes. The digested samples were left to cool overnight and the contents were transferred into a 50 ml volumetric flask and made up to the mark with distilled water. The samples were then filtered through a Whatman filter paper No.1 and finally transferred to 100 ml polypropylene bottles, ready for elemental analysis.

Evaluation of iron content of selected East African indigenous vegetables

Elemental analysis was done in three states: on raw AIVs, after boiling and after frying the AIVs. All the material was taken for analysis as there was no liquid left behind after cooking. Atomic Absorption Spectroscopy (AAS) was used where standards of each element (1000 parts per million) were diluted with 10% HCl. This was then aspirated directly using a Narian AAS Model at Mines and Geology department, Ministry of Natural Resources, Nairobi. Kenya (Gerge, 1984).

Data analysis

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

RESULTS

The formulated African indigenous vegetable recipes

Twenty East African indigenous vegetable recipes were formulated in the study. All these vegetable recipes

Table 1. Summary of the Fried Vegetable Recipes.

Recipe	Quantity of ingredients for each recipe
Nightshade with lye	½ kg AIVs for single vegetable recipes
Nightshade without lye	¼ kg AIVs for vegetable combination recipes
Cowpea with lye	¼ liter of water
Cowpea without lye	1 medium diced onion
Slenderleaf with lye	1 tbsp vegetable oil
Slenderleaf without lye	2 medium tomatoes
Amaranth with lye	2 tbsp table salt
Amaranth without lye	3 tbsp traditional salt (lye)
Nightshade and Amaranth with lye	
Nightshade and Amaranth without lye	
Nightshade and Slenderleaf with lye	
Nightshade and Slenderleaf without lye	
Nightshade and Cowpea with lye	
Nightshade and Cowpea without lye	
Amaranth and Slenderleaf with lye	
Amaranth and Slenderleaf without lye	
Amaranth and Cowpea with lye	
Amaranth and Cowpea without lye	
Slenderleaf and Cowpea with lye	
Slenderleaf and Cowpea without lye	

Table 2. Iron content (mg/g) of selected AIVs under different treatments.

AIVs	Raw	Boiled with lye	Boiled no lye	Fried with lye	Fried no lye	Average
Nightshade	17.3	12.4	11.5	281.2	401.6	144.8^{ab}
Cowpea	24.1	20.6	15.3	16.7	1208	256.94^{ab}
Slenderleaf	14.7	10.7	6.4	110	5.8	29.52^{b}
Amaranth	19.4	95.2	12.4	108	5.3	48.06^{b}
Nightshade and Amaranth	20.5	11.5	11.5	9.1	42.3	18.98^{b}
Nightshade and Slenderleaf	13.2	12.2	13.9	5.1	8.2	10.52^{b}
Nightshade and Cowpea	23.3	69.2	200.4	381.4	6.6	136.18^{ab}
Amaranth and Slenderleaf	12.5	23.6	557.5	859.2	859.2	469.6^{a}
Amaranth and Cowpea	20.1	69.2	16.6	7.2	303	83.22^{b}
Slenderleaf and Cowpea	14.7	26.9	9.1	10.1	8.1	13.78^{b}
Average	17.98	35.15	85.46	178.8	284.81	120.44
Significance Level						0.05
LSD						348.28
Interaction			Cooking Method*Lye			ns
			Cooking Method*AIV			ns

NB: Traditional Salt (Lye) = 7.2 mg/g.

(Table 1) were prepared using the same methodology.

Iron content of commonly consumed African indigenous vegetables

Iron content of selected AIVs and its combinations are indicated on Table 2 and it is demonstrated that cooking has released more extractable iron in African indigenous vegetables. There were no significant interactions between cooking method with AIVs (Table 2); however a combination of amaranth and slenderleaf had significantly higher iron solubility. Apart from nightshade with amaranth, nightshade with slenderleaf and amaranth with cowpea, all other AIVs had their iron solubility enhanced after frying (Table 2).

Whether the vegetables were cooked as single vegeta-

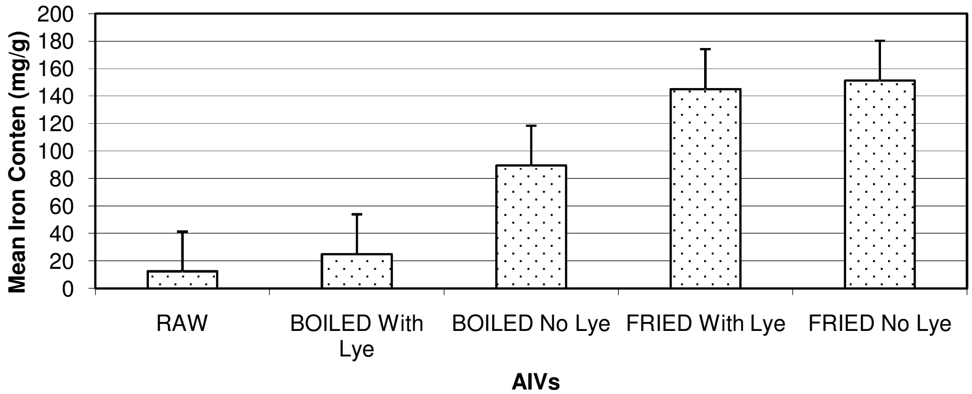

Figure 1. General effect of cooking and cooking method on iron content of AIVs.

bles or as a combination of two vegetables did not have an effect on their iron solubility (Table 2), some vegetables had higher iron content as single vegetables while others had higher content when combined with others. For example, a combination of amaranth and slenderleaf boiled without lye, fried with lye and fried without lye had the highest extractable iron of 557, 859.2 and 859.2 mg/g, respectively compared to amaranth and slenderleaf alone (Table 2).

Raw African indigenous vegetables had the least mean iron content compared to the boiled and the fried AIVs. Recipes prepared without traditional salt, recorded higher mean iron content for fried (without lye 284.8 + 427, with traditional salt 272.7 + 382.6) compared to mean iron content for boiled (without traditional salt 85 + 176, with traditional salt 30.7 + 28.4). Fried AIVs had higher mean iron content compared to the boiled (Figure 1). Paired sample t-test was applied and the results indicated that fried AIVs had significantly higher iron content compared to the boiled AIVs ($P < 0.05$). The difference in mean iron content between AIVs fried with lye and those fried without lye was insignificant ($P > 0.05$).

DISCUSSION

Formulation of African indigenous vegetable recipes

Lack of variety in recipe formulation has in the past been an obstacle towards AIV consumption and marketability according to Abukutsa-Onyango et al. (2006) and Shiundu and Oniang'o (2007). Therefore availability of AIV recipes could pave way for increased AIV consumption, ensure availability throughout the year and improve marketability.

Iron content of commonly consumed AIVs

Results indicate that cooking increase iron in AIVs; this concur with the experimental findings of Imungi and Poter (1983)(as cited by Abukutsa-Onyango, 2003) which showed increase in iron content of some African indigenous vegetables after cooking. This is because the heat exposes solubility of iron thus aids its bioavailability. The recommended daily intake (RDI) for iron content is between 10 to 8 mg (NIN, 1992; Abukutsa-Onyango, 2003); (Table 2) most formulated recipes could supply the recommended daily intake.

A study carried out by Weinberger and Msuya (2004) indicated that raw amaranth and nightshade contain iron content of 37.05 and 8.90 mg/g, respectively; this slightly varies with the results of this study, which indicate iron contents of 19.4 and 17.3 mg/g respectively. The possible explanation for the slight differences in iron contents could be due to the differences in type of vegetable and place (plots) where they were obtained (Weinberger and Msuya, 2004).

Combining vegetables during preparation have different effects on different vegetables (Table 2) in terms of their iron solubility and this could be attributed to different nutrient-nutrient interactions between different vegetables. Frying significantly ($P < 0.05$) increased iron solubility (Table 2); this could be attributed to the increased cooking time and also more iron could have been generated from the onions and tomatoes used during frying which are known to contain 1.48 and 1.99 mg/100g of iron, respectively (Sehmi, 1993) and vitamin A in the oil that increase iron solubility.

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