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Type of pots used in cooking may influence the iron content of commonly consumed vegetables in Nigeria: A laboratory based comparative study

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Kayode Ajayi[1], Oluwafemi K. Fabusoro[2], Israel O. Dada[1], Justina Y. Talabi[1], Risikat I. Fadare[3]*

Department of Human Nutrition and Dietetics, College of Medicine and Health Sciences, Afe Babalola University, Ado Ekiti, Nigeria. P.M.B. 5454, Ado-Ekiti[1]; Department of Human Nutrition, College of Medicine, University of Ibadan, Ibadan[2]; Department of Nursing Sciences, College of Medicine and Health Sciences, Afe Babalola University, Ado Ekiti[3]

***For Correspondence:** Email: *ajayikayode@abuad.edu.ng*

Abstract

Iron deficiency anemia is a major public health problem, especially in resource-poor countries. Cooking pots may contribute some appreciable amount of trace metals into food by way of leaching. The effects of iron and aluminum cooking pots on iron content of two commonly consumed vegetables were investigated. The pH content was determined using pH meter while the moisture was determined using a moisture content analyzer. The iron content was determined using Atomic Absorption Spectrophotometer (AAS). The mean difference in the pH of African spinach (V_A) 7.2±0.0 and Lagos spinach (V_L) 7.2±0.0 was not significant ($p>0.05$). The mean moisture content of African spinach and Lagos spinach were 8.7±0.0 g/100g and 18.2±0.1 g/100g respectively. The difference in the moisture content was however statistically significant ($p<0.05$). The iron content of African spinach boiled in aluminum pot [V_A (Al)] (5.9±0.0 mg/100g) was statistically different from the fresh sample of African spinach, V_A (12.7±0.2 mg/100g) ($p<0.05$) but the amount of iron lost as a result of boiling in aluminum pot was 6.8mg / 100g. The iron content of African spinach boiled in iron pot [V_A (Fe)] (15.9±0.0 mg/100g) was also statistically different from the fresh sample of African spinach ($p<0.05$). However, the amount of iron added (leached) as a result of boiling was 3.2 mg/100g. The same trend was observed in the Lagos spinach boiled in aluminum and iron pots. However, the iron lost as a result of boiling in aluminum pot (0.2 mg/100g) was not significant ($p>0.05$) while a greater amount of iron (5.5 mg/100g) was added (leached) when Lagos spinach was boiled in iron pot. Cooking in iron pots will conserve iron during boiling and improve iron intake from the vegetables. *(Afr J Reprod Health 2023; 27[6s]: 138-142).*

Keywords: Iron, green leafy vegetables, iron deficiency anemia, cooking pots

Résumé

L'anémie ferriprive est un problème majeur de santé publique, en particulier dans les pays pauvres en ressources. Les marmites peuvent apporter une quantité appréciable d'oligo-métaux dans les aliments par lessivage. Les effets des marmites en fer et en aluminium sur la teneur en fer de deux légumes couramment consommés ont été étudiés. La teneur en pH a été déterminée à l'aide d'un pH-mètre tandis que l'humidité a été déterminée à l'aide d'un analyseur de teneur en humidité. La teneur en fer a été déterminée à l'aide du spectrophotomètre d'absorption atomique (AAS). La différence moyenne de pH des épinards africains (VA) 7,2 ± 0,0 et des épinards de Lagos (VL) 7,2 ± 0,0 n'était pas significative (p> 0,05). La teneur moyenne en humidité des épinards africains et des épinards de Lagos était respectivement de 8,7 ± 0,0 g/100 g et de 18,2 ± 0,1 g/100 g. La différence de teneur en humidité était cependant statistiquement significative (p<0,05). La teneur en fer des épinards africains bouillis dans une marmite en aluminium [VA (Al)] (5,9 ± 0,0 mg/100 g) était statistiquement différente de celle de l'échantillon frais d'épinards africains, VA (12,7 ± 0,2 mg/100 g) (p < 0,05) mais la quantité de fer perdue à la suite de l'ébullition dans une marmite en aluminium était de 6,8 mg / 100 g. La teneur en fer des épinards africains bouillis dans une marmite en fer [VA (Fe)] (15,9 ± 0,0 mg/100 g) était également statistiquement différente de l'échantillon frais d'épinards africains (p<0,05). Cependant, la quantité de fer ajoutée (lessivée) à la suite de l'ébullition était de 3,2 mg/100 g. La même tendance a été observée dans les épinards de Lagos bouillis dans des marmites en aluminium et en fer. Cependant, le fer perdu à la suite de l'ébullition dans une marmite en aluminium (0,2 mg/100 g) n'était pas significatif (p>0,05) tandis qu'une plus grande quantité de fer (5,5 mg/100 g) était ajoutée (lessivée) lorsque les épinards de Lagos étaient bouillis dans marmite en fer. La cuisson dans des marmites en fer permet de conserver le fer pendant l'ébullition et d'améliorer l'apport en fer des légumes. *(Afr J Reprod Health 2023; 27[6s]: 138-142).*

Mots-clés: Fer, légumes à feuilles vertes, anémie ferriprive, marmites

Introduction

Anaemia, characterized by low blood-hemoglobin concentration is a key public health concern prevalent among low, middle as well as high-income countries, worldwide[1]. Almost 1.62 billion people are affected with anemia, which approximates to 24.8% of the world's population[1]. According to the Global Database, anemia is most frequent among children under five (39.8%), followed by pregnant (36.5%) and non-pregnant (29.6%) women. There are various underlying causes of anemia, of which the most significant is iron deficiency anemia (IDA). Available data indicate that up to 50% of anaemia may be attributable to deficiency of iron[1,2]. A WHO report estimates that 35% to 80% of pregnant women in developing countries are anaemic: notably, in Nigeria (60% pregnant women are anaemic); Tanzania (86% pregnant women have iron deficiency anaemia while one-third of the anaemic women had malaria). In coastal Kenya, 75.6% were found to be anaemic while 9.8% were severely anaemic[3]. Also a WHO study in Guinea during 2000-2006 revealed that 58% of pregnant women who died during child birth were anaemic while only 18% of pregnant women from industrialized countries is anaemic.

Iron deficiency occurs predominantly due to malnutrition and it is commonly observed in a section of people with rapid rate of growth[4]. Iron deficiency anaemia (IDA) also has adverse effects on cognitive and motor development, which leads to low productivity and fatigue[2]. Thus, it is important to address this as a major public health problem. Vegetables, not only enhance the sensory attributes, but also enriches the nutritional quality of diets because of their richness in vitamins and phytochemicals[5]. Green leafy vegetables are not only rich in iron content but are also available at low cost. Leafy vegetables are often consumed in cooked form and very few vegetables are consumed in raw form. Cooking methods such as boiling and frying as well as the utensils used for preparations, have great role in altering the quality and bio-availability of different nutrients[6].

An earlier systematic review by Alves *et al* reported that the use of iron pot for preparing food may help to overcome the iron deficiency anemia in developing countries[7]. The nature of cooking wares, the cooking process, the storage and processing methods can increase trace metal levels in foods[8]. Other studies have shown that iron pot increases the total and available iron of foods[9]. Inadequate dietary iron from habitual diets is considered the single most important cause of the widespread micronutrient deficiency among the population[10].The availability of nutrients from vegetables gets altered when subjected to different processing methods that are in vogue at household levels. There are limited studies on the effect of cooking pot on the iron contents of vegetables in Nigeria, hence this study was designed to bridge the gap.

Methods

Two commonly consumed greens, namely, African spinach (*Amaranthushybridus*) and Lagos spinach (*Tricolor Amaranthus*) were used for this study. They were procured in a single lot from a local market (Bodija) in Ibadan, Nigeria.

Samples were bought randomly from retailers selling the vegetable and packed into polythene black bag from each sampling point. The polythene bags were quickly sealed with paper tape for proper protection against light and air interference. The samples were immediately taken to the laboratory for preservation. The polythene bag was properly labeled and a proper record keeping was taken. The vegetable samples were cleaned and washed with glass water after separating the non-edible portion. The thoroughly drained green vegetables were divided into three equal portions and were cut into 1 cm pieces using a stainless steel knife on a wooden cutting board. One portion was retained, as such, for analysis, which served as control (raw). The other two portions were cooked in iron, and aluminum pots, respectively, using the open-pan method of cooking. Green vegetables were boiled until they became soft, i.e. judged by finger feel. Time taken for boiling depends on the gauge, heat penetration and retention by the metal. Iron utensils required comparatively shorter cooking time due to better heat retention while in the aluminum pot, water uptake was high due to faster heat penetration.The cooked and fresh greens were analyzed for moisture[11].The air oven method was used to determine this moisture content. A known weight of the sample (3g) was put in a washed, dried and cooled crucible and this was dried at 60°C until a constant weight was obtained. This was allowed to cool in a desiccator and the difference in weight was used to calculate the moisture content. The pH was determine using Cole Parmer pH meter model 5850-00 and the iron content was also determined using Atomic Absorption Spectrophotometer (AAS). The procedure laid out by Kirk and Sawyer[12] was applied. The sample was weighed into a clean crucible in a little amount (0.2g), and the organic material was burned off in an open flame before being transferred to a muffle boiler and left to ash for six hours at 600°C until the ash entirely turned white. This was then warmed on a heater for a brief period of time to prevent foaming before being washed with 10 ml of 0.1N HCl into a 100 ml volumetric flask. This was filtered into a second 100ml volumetric flask, and the filterate's volume was increased to 100ml by adding distilled water. This was atomized in the air-acetylene flame after being aspirated through the nebulizer. The quantity of energy absorbed in the flame was proportional to the concentration of the mineral in the sample throughout a constrained concentration range using particular sources of lamp (of an Atomic Absorption Spectrophotometer) for each element or mineral.

Data analysis

Data were subjected to a suitable statistical test. T-test was used to analyse the differences between the constituents of the green leafy vegetables cooked in different utensils and these were performed at 5% level of significance.

Result

The results of the study are summarized in tables 2-4. The pH content of African spinach boiled in aluminum pot [V_A (Al)] and the sample boiled in iron pot [V_A (Fe)] were 7.2 ± 0.0 and 7.3 ± 0.1 respectively while the iron content are 5.9 ± 0.0mg/100g and 15.9 ± 0.0 mg/100g respectively. The *P* value of the pH is not statistically significant (P>0.5) while the iron content of the vegetable boiled in different pot is considered statistically significant (p<0.5).

Table 1: Sample code assigned to different vegetables

Code	Vegetable
V_A	African spinach (*Amaranthus hybridus*)
V_L	Lagos spinach (*Tricolor Amaranthus*)

Table 2: pH, moisture content and iron content of fresh vegetables (African spinach and Lagos spinach)

	V_A Mean±SD	**V_L Mean±SD**	**p-value**
pH	7.2± 0.0	7.20 ± 0.0	0.93
Moisture content (g/100g)	8.7 ± 0.0	18.2 ± 0.1	0.0001
Iron content (mg/100g)	12.7 ± 0.2	8.0 ± 0.0	0.0001

Key: V_A =African spinach (raw) V_L= Lagos spinach (raw)

The pH content of Lagos spinach boiled in aluminum pot [V_L (Al)] was 7.3 ± 0.0 while the pH of the same sample that was boiled in iron pot [V_L (Fe)] was 7.3±0.1. The iron content of Lagos spinach boiled in aluminum pot [(V_L) (Al)] and the iron content of Lagos spinach boiled in iron pot [V_L (Fe)] were 7.8±0.1 and 13.5±0.0 respectively. However, the mean difference between the pH values was statistically not significant (*P*>0.05).

The iron content of raw African spinach (V_A) was 12.7 ± 0.2 mg/100g while the raw sample of Lagos spinach (V_L) was 8.0 ± 0.0 mg/100g.

After boiling in two different cooking pots (aluminum and iron pot), the amount of iron that was lost from the African spinach cooked in aluminum pot [V_A(Al)] was 6.8mg/100g while the amount of iron that was leached (contaminant iron) from the African spinach cooked in iron pot [V_A (Fe)] was 3.2 mg/ 100g.

The iron content of Lagos spinach that was lost after boiling in aluminum cooking pot [V_L(Al)] was 0.2mg/100g. However, boiling in iron pot [V_L(Fe)], increased the iron content of the vegetable by 5.5mg/100g. The iron lost as a result of boiling of Lagos spinach in aluminum cooking pot was however statistically not significant (p>0.05) but statistical difference was observed in the loss of iron for African spinach boiled in Aluminum pots and leached iron of African and Lagos spinach iron boiled in iron pot (p<0.05).

Table 3: pH and iron content of boiled vegetables (African spinach and Lagos spinach)

	African spinach			**Lagos spinach**		
	V_A (Al)	**V_A (Fe)**	**P-value**	**V_L (Al)**	**V_L (Fe)**	**P-value**
pH	7.2 ± 0.0	7.3 ± 0.1	0.90	7.3 ± 0.05	7.3± 0.1	0.95
Iron content (mg/100g)	5.9 ±0.0	15.9 ± 0.0	0.0001	7.8 ± 0.05	13.5 ± 0.0	0.0001

Key: V_A (Al) = African spinach boiled in Aluminum pot, V_A (Fe) = African spinach boiled in Iron pot V_L (Al) = Lagos spinach boiled in Aluminum pot, V_L (Fe) = Lagos spinach boiled in Iron pot

Table 4: Effect of boiling in cooking pot on the Iron content of boiled African spinach and Lagos spinach

Raw sample	**Iron content (mg/100g dry weight) (a)**	**Boiled sample**	**Iron content (mg/100g cooked) (b)**	**Change in iron content (mg/100g) (b) – (a)**	**P-value**
V_A	12.7± 0.2	**V_A(Al)**	5.9 ± 0.0	-6.8	0.0001
V_A	12.7± 0.2	**V_A (Fe)**	15.9 ± 0.0	+3.2	0.0014
V_L	8.0 ± 0.0	**V_L (Al)**	7.8 ± 0.1	-0.2	0.8415
V_L	8.0 ± 0.0	**V_L (Fe)**	13.5 ± 0.0	+5.5	0.0001

Key: V_A = African spinach (raw) V_L = Lagos spinach (raw)
V_A (Al) = African spinach boiled in Aluminum pot V_A (Fe) = African spinach boiled in Iron pot
V_L (Al) = Lagos spinach boiled in Aluminum pot V_L (Fe) = Lagos spinach boiled in Iron pot

Discussion

The results of this study indicate that much of the iron in the vegetables were lost through boiling in aluminum pot especially for African spinach (6.8 mg/100g). The recommended daily allowance of iron for adult male and female is 8 and 18mg/day respectively[13]. Cumulative loss of iron in cooking pots such as aluminum pots during the various daily cooking can lower this value which can lead to iron deficiency for consumers of such foods. It shows that consumers of foods cooked in these type of cooking pot (aluminum cooking pots) are likely prone to iron deficiency anemia.

However, an increase of 3.20mg/100g and 5.50 mg/100g of African and Lagos spinach were found when the vegetables were boiled in iron cooking pots. This amount is appreciable enough to boost iron intake in addition to iron from other food sources, thereby making consumers of foods cooked in iron cooking pot meet the recommended daily allowance. These findings are consistent with previous studies where increase in iron content of staples prepared in iron pots was observed[7]. In another systematic review there was an increase in iron content of foods cooked in an iron pan compared to those cooked in a non-sticky pot[14]. It has also been observed that bioavailability of iron from greens increased on cooking in iron pan irrespective of method of cooking. An increase in trace metal levels of processed food items cooked in iron cooking wares has also been observed[8]. Likewise, another study confirmed that iron cooking pots contribute to iron content of staple foods which formed an important part of the total dietary iron available for absorption. Furthermore, the consumption of vegetables with other food, as a part of the day's diet, should meet individual's daily requirement for iron.

Policy implications

Using cooking pots to prevent anaemia may have a few policy implications at the individual and community levels. Cooking in iron pots has been found to increase the iron content of food, which can help prevent iron-deficiency anaemia. Policies that promote the use of iron pots can help prevent anaemia. For example, governments can collaborate with manufacturers to make iron pots more affordable and accessible, provide subsidies to encourage their purchase, and promote their use through education and awareness campaigns.

Vulnerable populations, such as low-income families, may not be able to afford iron pots. Therefore, policies that provide iron pots to vulnerable populations, such as through food assistance programs or health clinics, can help prevent anaemia. Education and awareness campaigns can promote the benefits of using iron pots for cooking and encourage their use. Governments can collaborate with healthcare providers, schools, and community organizations to spread awareness about the importance of using iron pots to prevent anaemia. Governments can develop monitoring and evaluation systems to assess the prevalence of anaemia and its determinants in the population. These systems can help identify populations at high risk of anaemia and assess the effectiveness of policies promoting the use of iron pots.

Overall, using cooking pots to prevent anaemia is a simple and affordable intervention that can have significant health benefits. Policies that promote the use of iron pots can help prevent anaemia and improve overall health outcomes, particularly among vulnerable populations.

Conclusion

This study has shown that vegetables cooked in iron pots can contribute to increase iron content of the diet and can be considered as an economic and convenient way of improving iron status. Further research in the field is required to confirm the findings in other foods as the availability varies from one food to another. This can be considered as a strategy in reducing iron deficiency anemia, a major public health problem.

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