In-Vitro Availability of Iron and Proximate Composition of Some Under-Exploited Green Leafy Vegetables of Southern Guinea Savanna of Nigeria

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Abstract

Six locally consumed, little known, under-exploited green leafy vegetables of southern guinea savanna of Nigeria were studied at three locations in a farmer-managed local vegetable farms in Makurdi during 2003 and 2004 cropping seasons. The vegetables included: Celosia trigyna, L. – Amaranthaceae; Crassocephalum biafrae (Olive and Heim) S. Moore – Compositae; Crassocephalum crepidoides (Benth) S. Moore – Compositae; Basella alba L. – Basellaceae; Solanum nigrum L. – Solanaceae and Lactuca taraxacifolia Schum ex Hornmann – Compositae. The objective was to determine proximate composition and iron availability in these non-conventional vegetables. Data recorded for two years were pooled and subjected to analysis of variance procedures for randomized complete block design. Results showed that the in-vitro available iron ranged between 2.8 and 4.6% of the total iron content of the vegetables. Increase in ascorbic acid content did not increase the availability of iron. Vegetables containing very large amounts of oxalate tended to decrease their iron availability. The crude protein and ether extract (fat) were highest in S. nigrum while the ash and crude fibre contents were highest in C. crepidoides and B. alba; L. taraxacifolia, respectively. The highest dry matter content and nitrogen free extract (carbohydrate) were recorded in C. biafrae. These vegetables meet the Recommended Dietary Allowance Standard and should be included in research programmes for efficient vegetable production in Nigeria.

Keywords: Iron availability, leafy vegetables, proximate composition

Introduction

Research programmes on green leafy vegetables in Nigeria has so far covered only the routinely cultivated ones such as Fluted pumpkin (*Telfaria occidentalis* [F.] Hooks); Red sorrel or Indian sorrel (*Hibiscus sabdarifa* L.); Corchorus or vegetable jute (*Corchorus olitorius* L.); Celosia or Cock's comb (*Celosia argentea* L.); Local garden egg (*Solanum macrocarpon* L.); Green amaranth (*Amaranthus spp.* L.) and Water leaf (*Talinum triangulare*) (NIHORT, 2000). It is a common knowledge that leafy vegetables and fruits are the richest sources of vitamins and minerals and some can also provide adequate quantities of carbohydrates and protein (AVRDC, 1998). The malnutrition problems in Nigeria although different in magnitude and severity among different areas are due to protein, vitamins, iron and other minerals deficiency. To solve these problems, Ologunde *et al.*, (1992) stressed the need for identifying novel high quality but cheap sources of proteins, vitamins, minerals and energy in the third world countries, especially Nigeria because the commonly cultivated or existing vegetable sources have failed to meet the demand for these nutrients in human diet. This therefore calls for identifying a broader range of plant species which have potential as major food sources and for developing these for efficient food production in the Nigerian economy. Obasi (1991) noted that protein malnutrition which is a serious problem in Nigeria has prompted a revival of interest in food legumes that the search for high quality, inexpensive sources of protein has continued to be a major concern of agriculturists and government bodies.

In Nigeria, there have been several reports on chemical studies of leafy vegetables (Gupta *et al.*, 1989; Ologunde *et al.*, 1992; Badifu and Okeke, 1992; Esuoso *et al.*, 1998). However, there has not been any report on chemical studies of under-exploited leafy vegetables used in this study. It has been reported that high iron content in vegetables serves a great purpose in metabolism and skeletal growth, blood haemoglobin formation and enzyme system activities respectively in man (AVRDC, 1984).

There is a dearth of information on the in-vitro availability of iron from these leafy vegetables in Nigeria. This study therefore investigated in-vitro availability of iron and proximate composition in various under-explored green leafy vegetables of southern guinea savanna of Nigeria.

Materials and Methods

Collection of vegetables: Six locally consumed green leafy vegetables studied were:- Silver spinach (*Celosia trigyna* L.) – Amaranthaceae; Black nightshade (*Solanum nigrum* L.) – Solanaceae; Bitter African spinach (*Lactuca taraxacifolia* Schum ex Hornmann) – Compositae; Wild Sierra Leone bologni (*Crassocephalum crepidoides* [Benth] S. Moore) – Compositae; Sierra Leone bologni (*Crassocephalum biafrae* [Olive and Heim] S. Moore) – Compositae; Ceylon spinach (white) (*Basella alba* L.) – Basellaceae. They were grown in a farmer-managed local vegetable farms located at three sites: Wurukum, Northbank and Wadata areas of Makurdi, Benue State, Nigeria.

Fresh samples for each vegetable were collected from 2m x 2m dimension plots during the cropping seasons of 2003 and 2004. Each vegetable farm location served as a replicate.

Only the succulent shoot parts of the vegetables which are eaten were cut, bagged separately and taken to Crop Science/Nicansol Laboratory of the University of Agriculture, Makurdi. The samples were washed in 0.1% Omo detergent solution followed by immediate rinsing with distilled water to remove all spray residues and contaminants on the leaves. The samples were thereafter air-dried for one hour before processing.

Processing of vegetables: 1. Each vegetable species weighing 100g was boiled in 250 ml distilled water and an aliquot of the boiled solution was taken for analysis. In-vitro availability of iron was calculated from ionisable ions. Since ascorbic acid and oxalic acid influence the availability of iron (NAS, 1980), these constituents were determined and their relationship to the in-vitro availability of the iron content was studied.

Total iron was estimated using thiocyanate (AOAC, 1990), and ionisable iron using the in-vitro method proposed by Narasinga Rao and Prabhavathy (1987), and the in-vitro availability of iron was calculated from the ionisable iron using the prediction equation.

$$Y = 0.4827 + 0.4707x$$

Where Y is % in-vitro available iron and x is the the % ionisable iron (Narasinga Rao and Prabhavathy 1987). The in-vitro available iron calculated from the in-vitro studies has been shown to correlate well with results from in-vivo studies (NAS, 1980).

Ascorbic acid was estimated by the 2, 6-dichlorophenol indophenols dye method (AOAC, 1990), and oxalate content was determined by the method proposed by the Indian National Institute of Nutrition (Raghuramulu *et al.*, 1983).

2. Each vegetable species weighing 250g was put in an oven at 80^0C for 72 hours to determine the dry matter (DM) contents. The dried samples were ground separately in a Wiley microhammer stainless steel mill. The ash content was determined by igniting 2.0g of the ground sample in muffle furnace at 500^0C for two hours (AOAC, 1990). The crude fibre (CF) content was determined by digesting 2.0g of the ground sample in boiling 1.25% H_2SO_4 and 1.25% NaOH (AOAC, 1990). The ether extract (EE) was determined by soxhlet extraction technique. The crude protein (CP) content was determined by first determining the nitrogen (N) content by micro-Kjeldahl method and multiplying the N value by 6.25 (AOAC, 1990). The nitrogen-free extract (NFE) was determined by summing up the percentage ash, CF, EE, and CP and deducted from 100 (IITA, 1984).

All data collected were subjected to analysis of variance based on the standard method for the randomised complete block design (Steel and Torrie, 1980). The treatment effects were compared either by the F-LSD procedure (Carmer and Swanson, 1971) or the Duncan's New Multiple range Test at 5% level of probability.

Results

The results of total, ionisable and in-vitro available iron, ascorbic acid and oxalic acid in the vegetables are given in Table 1. There was a wide variation in the total iron content of green leaf vegetables of nearly three-fold, but the in-vitro available iron ranged between 2.8 and 4.6% of it. There was no increase in the availability of iron with increasing ascorbic acid content but there was a trend towards decreased iron availability from the green leaf vegetables containing very large amounts of oxalate.

The proximate composition of the green leafy vegetables, on per cent dry matter basis is presented in Table 2. The dry matter content of *C. biafrae* is significantly higher than for *B. alba*, *C. crepidoides* and *S. nigrum* by 37.4%, 41.1% and 25.4% respectively. The crude protein content of *S. nigrum* is significantly higher than for other vegetables except *L. taraxacifolia*. Comparison showed that the crude protein content of *S. nigrum* was 26.6%, 20.1%, 18.4% and 9.5% more than for *C. biafrae*, *B. alba*, *C. crepidoides* and *C. trigyna*, respectively. The ether extract content of the vegetables followed closely the pattern of crude protein content. The highest ether extract content of *S. nigrum* was 70.0% higher than the least of *C. biafrae*. The highest nitrogen free extract content (61.2) of *C. biafrae* was 17.0% higher than the least (52.3) of *L. taraxacifolia*. Also, the highest crude fibre content of *B. alba* (16.4) was 56.2% higher than the least of *C. biafrae* (10.5). The ash content of *C. crepidoides* was significantly ($P<0.05$) higher than for other vegetables studied. Comparison showed 55.1% more ash in *C. crepidoides* than *S. nigrum* and *B. alba*.

Discussion

The results of the present study indicated that the in-vitro available iron of different green leaf vegetable was neither a function of their total iron content nor related to their ascorbic acid content. However, there was some indication that oxalate might affect the availability of iron. The oxalate content of green leaf vegetable and their in vitro available iron are similar to the reports of Gillooly *et al.*, (1987) who observed that the absorption of iron from the vegetables namely spinach, beetroots, and beetroot greens, which contain large amounts of oxalate (4.6, 3.4 and 9.2 g kg^{-1}) respectively, was low in comparison with other vegetable such as cauliflower, cabbage, carrot, green lentils. However, they found no correlation between oxalate content and iron absorption from these vegetables. They suggested that polyphenols may also exert an effect on iron absorption. Similarly, Rackis *et al.* (1986) noted that polyphenols depress the biological value of dietary proteins and hinder mineral adsorption from the diet. The present study indicated that the availability of iron from these non-conventional leaf vegetables are similar to those observed from the conventional green leaf vegetables (AVRDC, 1998).

Table 1: Total, Ionisable and in-vitro available iron, ascorbic acid and oxalic acid in six under-exploited green leafy vegetables of southern guinea savanna of Nigeria (Mean ± SEM)

Green leaf vegetable	Total iron (mg kg^{-1})	Ionisable iron (% total Fe)	In-vitro available iron (% total Fe)	Ascorbic acid (mg kg^{-1})	Oxalic acid (g kg^{-1})
B. alba	99 ±5.4	4.9±0.52	2.8±0.26	992±12.5	7.83±17.5
C. crepidoides	160±5.4	6.6±0.26	3.6±0.13	641±13.8	0.94±13.4
L. taraxacifolia	125±8.1	6.2±0.44	3.4±0.22	1525±12.5	1.01±18.1
S. nigrum	51±1.1	8.8±1.20	4.6±0.56	571±11.5	0.16±2.9
C. biafrae	109±4.1	7.0±0.32	3.7±0.17	265±10.1	2.08±14.1
C. trigyna	66±5.4	5. 0±0.42	2.8±0.22	290±5.4	6.62±24.0

Table 2: Proximate composition of six under-exploited green leafy vegetables of southern guinea savanna of Nigeria

Green leaf vegetable	Dry matter (%)	Crude protein (%)	Ether Extract (%)	Crude fibre (%)	Ash (%)	Nitrogen free extract (NFE) (%)
B. alba	11.5d	13.4cd	3.6cd	16.4a	10.7e	55.9a
C. crepidoides	11.2d	13.6c	3.5cd	10.7c	16.6a	55.6a
L. taraxacifolia	14.7b	15.4ab	5.0ab	16.3a	11.0d	52.3c
S. nigrum	12.6c	16.1a	5.1a	11.6b	10.7e	56.5a
C. biafrae	15.8a	12.7d	3.0d	10.5c	12.6c	61.2b
C. trigyna	15.4ab	14.7b	4.6abc	11.7b	11.4c	57.6a

Each value is a mean of six analysis (Duplicate sample x 3 replicates). Means followed by different alphabets in each column are significantly different at 5% level of probability

The results of proximate composition generally agreed with those reported by Oke (1966) for *Heinsia pulchelia*, *Gynura amplexcaulis*, *Solanum nodiflorum* and *Myrianthus arboreus*. The slight difference obtained particularly with respect to nitrogen free extract (carbohydrate) and crude protein may be due to genetic differences between the vegetables used by Oke (1966) and those used in this study. However, apart from the genetic difference, Oke (1968) showed that the age at sampling has an effect on the proximate composition of vegetables as the dry matter, crude protein, crude fibre and ash content increased with age in *Corchorus olitorius*, *Celosia argentea*, *Solanum incanum* and *Solanum macrocarpon*. Also, Purseglove (1987) reported that the nutrient composition of plant materials vary with the age, cultural practices, environment, the season and the varieties.

The crude protein, nitrogen free extract and ether extract obtained in the present study are consistent with those reported by Ologunde *et al.,* (1992) for grain amaranth. The values obtained by Ologunde *et al.,* (1992) are found to be consistent with the United States Recommended Dietary Allowance (RDA). It could therefore be inferred that some proportion of the dietary protein, ether extract (fat) and nitrogen free extract (carbohydrate) requirements of man could be met by these non-conventional leafy vegetables if a sufficiently large amount is eaten.

In general, all the six locally consumed green leafy vegetables studied compare favourably both in terms of availability of iron and proximate composition with *S. macrocarpon*, *T. occidentalis*, *A. cruentus*, *C. argentea*, *C. olitorius* and *H. sabdarifa* which are routinely cultivated and have been reported by NIHORT (2000) and AVRDC (1998). The leaf yields of *B. alba* (29.7 t ha^{-1}) used in this study compare with *S. macrocarpon* (27.2 t ha^{-1}) while those of *C. biafrae* (38.6 t h^{-1}), *C. crepidiodes* (23.9 t ha^{-1}), *L. taraxacifolia* (26.7 t ha^{-1}) and *C. trigyna* (28.4 t ha^{-1}) compare favourably with *T. occidentalis* (40.4 t ha^{-1}), *A. cruentus* (26.8 t ha^{-1}), *C. argentea* (24.6 t ha^{-1}) and *H. sabdarifa* (28.4t ha^{-1}), respectively (NIHORT, 1988).

Conclusion: The proximate composition and availability of iron of the six locally consumed vegetables studied meet the Recommended Dietary Allowance (RDA) standard and are thus capable of meeting the nutritional need of the poor people who cannot pay for milk, egg and meat but depend on cheap vegetables as the main source of their dietary needs. The leaf yields obtained are also promising and compare favourably with the commonly cultivated vegetables that are included in research programmes. It is suggested that the vegetables used in the present study should be included in the vegetable research programmes especially for improvement/breeding.

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