THE NUTRIENT CONTENT OF FIVE TRADITIONAL SOUTH AFRICAN DARK GREEN LEAFY VEGETABLES - A PRELIMINARY STUDY

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ABSTRACT

The nutrient content (proximate, vitamin B_2, ß-carotene, iron, zinc, magnesium, calcium and phosphorus) of five traditional dark green leafy vegetables, traditionally consumed by rural inhabitants of South Africa (SA), was determined in this study. The nutritional dilemma in SA, with many children and adults suffering from micronutrients deficiencies, is a strong motivator for indicating the nutritional composition of traditional foods. The moisture, protein, ash and fat content in the raw leaves per 100g ranged from 81.0 – 89.9 g/100g, 3.49 – 5.68 g/100g, 1.42 – 3.23 g/100g and 0.12 – 0.36 g/100g respectively. There was an increase in moisture content in the cooked leaves while the protein, fat and ash decreased during the cooking process. Raw misbredie (*Amaranthus tricolor),* pumpkin leaves *(Curcubita maxima)* and cat's whiskers *(Cleome gynandra)* had a high iron content compared to cowpea leaves (*Vigna unguiculata)* and wild jute (*Corchorus olitorius),* which in nutritional terms might play a role in combating iron deficiency in SA. The zinc content ranged from 0.5 towards 1.0 mg/100g while the magnesium ranged from 54.7 mg to 146 mg/100g. As expected the minerals decreased during cooking. Cowpea leaves was the poorest source of minerals compared to the other leafy vegetables but had a good index of nutritional quality for protein. Raw and cooked *pumpkin leaves* had the highest index of nutritional quality for protein. Both raw and cooked leafy vegetables contained high levels of beta-carotene (with total beta-carotene levels in the range of 796 – 6134µg/100g) but low levels of vitamin B_2 (0.01 – 0.12 mg/100g).

Key words: Nutrient content; Traditional dark green leafy vegetables, *Amaranthus tricolor, Cleome gynandra, Crochorus olitorius, Curcubita maxima, Vigna unguiculata*

1. INTRODUCTION

Food insecurity is one of the main reasons causing malnutrition in South Africa (SA), with 1 in 2 households in SA experiencing hunger as determined by the hunger scale. Furthermore, in 2005 one third of South Africans were at risk of hunger, and only one out of every five people were

recorded to be food secure (NFCS-FB-1, 2008; Schönfeldt *et al.,* 2010). According to the 1999 National Food Consumption Survey (NFCS, 1999) one out of every nine children are underweight and one out of five children were stunted at national level (Labadarios *et al.,*1999). The majority of SA households consume a limited variety of foods, mainly consisting of staples, and in 200385% of the households in SA purchased all the foods they consume. Only 5% of households have been indicated to grow their own food for consumption (UWC, 2003). The recent significant increase in food inflation is recognized as one of the main contributors to food insecurity, leading towards an abundant food supply that people cannot afford to buy (Schonfeldt *et al.*, 2010). The importance of food coping strategies, like planting and harvesting, own food thus strongly comes into focus,

Surveys indicate that there are over 7 000 plant species across the world that are cultivated or harvested from the wild for food. These neglected and underutilized species play a crucial role in food security, income generation and food culture of the rural poor. Lack of attention in the past has meant that their potential value is mostly under-estimated and under-exploited. Many neglected and underutilized species are nutritionally rich and are adapted to low input agriculture (IPGRI, 2000 – 2005). Food insecurity can be reduced by motivating communities to increase their consumption of indigenous and traditional dark green leafy vegetables (IPGRI, 2000 – 2005). However, to recommend these foodstuffs as contribution to an improved diet, knowledge about the nutrient content of the traditional vegetables is required. The values currently in the South African Medical Research Council's tables (Kruger et al., 1998) are based on a limited amount of plants tested in Venda in one specific region (Limpopo province) of SA. It should also be considered that soil and climatic conditions of different regions results in a significant difference in food composition of foods produced (Greenfield & Southgate, 2003) and therefore data cannot simply be borrowed between countries.

In order to enhance current nutrition education programs in SA, knowledge of the nutrient composition of the traditional vegetables is essential. Due to financial constraints the nutrients analyzed were limited to those nutrients that were high in these species according to previous studies done in other parts of the world. This study aimed at determining the content of selected nutrients (protein, fat, ash, moisture, vitamin B_2, ß-carotene, iron, zinc, magnesium, calcium and phosphorus) contained in five commonly consumed indigenous dark green leafy vegetables, namely misbredie (*Amaranthus tricolor),* pumpkin leaves *(Curcubita maxima),* cat's whiskers *(Cleome gynandra),* cowpea leaves (*Vigna unguiculata)* and wild jute (*Corchorus olitorius*). The analysis was done on both raw and cooked samples to enable determining the effect of traditional cooking practices on nutrient content.

2. Materials and methods

2.1. Selection of species

The Agricultural Research Council (ARC) at Roodeplaat identified the five traditional vegetables most commonly consumed by rural communities as part of the Sustainable Rural Livelihood Program (SRL) in SA. The five vegetables that were identified were *Amaranthus tricolor* (misbredie)*, Corchorus olitorius* (wild jute), *Cleome gynandra* (cat's whiskers)*, Cucurbita maxima* (pumpkin leaves) and *Vigna unguiculata* (cowpea leaves)*.*

2.2. Collection of samples

All the leaves, grown in similar soil, were planted (March 2005), harvested and collected from ARC at Roodeplaat during May 2005. Chicken and cattle manure were used as fertilizers for all the plants. They were selected at random from the plant area and picked by hand mid-morning during autumn. A minimum of 800 grams per species was collected randomly from different plants within the field. The leaves were placed in black plastic bags and transported on ice in cooler boxes to the University of Pretoria for processing the same day.

2.3. Processing of samples

In the laboratory the edible and inedible portions of each sample were separated. The inedible portions were discarded. The edible portions were washed with tap water and rinsed with distilled water. The residual moisture on the leaves was evaporated at room temperature (± 25 °C) in the dark. The percentage edible portion of the plants was calculated. For all species, except cat's whiskers, the leaves were the only edible part used. For cat's whiskers the petiole and young stems form part of the edible portion (Jansen van Rensburg, *et al.,* 2004). Cowpea leaves was left outside overnight at room temperature, so as to conform to the local preparation method in which the leaves are usually harvested a day before it is cooked to shorten the cooking process (Vorster, Jansen van Rensburg, Van Zijl, 2002). The edible portions of all the vegetables were divided in two equal sub-samples. One sub-sample was cooked according to traditional recipes with the assistance of a cultural representative, and the other was kept raw for analysis.

The pumpkin leaves were chopped into edible pieces according to traditional cooking methods just before cooking, while the leaves of the other plants were cooked whole. An amount of water as indicated in table 1 was brought to the boil in a 24 x 11.5cm stainless steel pot. The leaves were boiled with the lid on till it was tender and suitable for consumption. Documentation of the cooking procedure was kept in terms of the amount of water and sample used, the cooking time,

and the amount of water and sample left after the cooking procedure (Table 1). Afer cooking the water was drained through a sieve and after cooling the leaves were transferred to marked plastic containers and send to the different laboratories for preparation and analyses.

2.4. Preparation of samples

2.4.1.   Proximate

Both the raw and cooked samples were prepared after drying the leaves overnight at 50 °C until constant weight was achieved. The dried leaves were milled and sieved through a 1mm stainless steel sieve to obtain a homogenized powder sample. coded, and stored in zip-lock plastic bags at – 20 °C. Analyses commenced within two weeks after every sampling.

2.4.2.   Minerals

Both the raw and cooked samples were oven dried in glass trays at 50 °C overnight until there was no further moisture loss. After the leaves had been powdered by hand with a porcelain mortar and pestle, they were milled and sieved through a 1mm stainless steel sieve to obtain a homogenized sample. Approximately ten gram of each of the sieved samples were stored in zip-sealed plastic bags and coded. The samples were stored at -20 °C until they were delivered at the ARC-Institute for Soil Climate and Water in Pretoria for the mineral analysis. Analyses commenced within two weeks after every sampling.

2.4.3.   Vitamins

The samples for the vitamin analysis were freeze dried for 72 hours and milled into a powder. They were vacuum-sealed and covered with foil to prevent oxidation. Storage instructions, code and vitamin concentration range were indicated on the vitamin analytical samples. The samples were stored at – 20 °C until it was send to the ARC-Irene Analytical Services and Medical Research Council (MRC-Cape Town) for vitamin B_2 and β-carotene analysis respectively. Analyses commenced within three weeks after every sampling.

2.5. Experimental conditions and procedures

2.5.1. Proximate analysis

The fat, ash and moisture content were determined at the Department of Food Science at the University of Pretoria. The moisture content of all the leaves, except cowpea leaves, was determined on the day the leaves were harvested according to the AOAC Official Method 931.15 (2000) in triplicate. The ash content was determined in duplicate by using the AOAC Official Method 942.05 (2000). The crude fat was determined in duplicate by extracting five gram samples in a Soxhlet apparatus using petroleum ether with a boiling point range of 40 – 60 ˚C.

The protein analysis was performed in duplicate by the Nutrilab at the University of Pretoria according to the Kjeldahl method and a conversion factor of 6.25 was used. The energy value was calculated by multiplying the mean values for the crude fat, protein and total carbohydrates by 37, 17 and 17 respectively (Greenfield & Southgate, 2003). The total energy content was calculated by taking the sum of the energy value of the crude fat, protein and total carbohydrates (Greenfields & Southgate, 2003).

2.5.2. Mineral analysis

Iron, zinc, magnesium and phosphorus were analyzed in duplicate with ICP-OES method at the ARC-Institute for Soil, Climate and Water. Approximately 0.5g of each freeze-dried sample were digested with the "Rapid Nitric-Perchloric Acid Digestion Method". This digestion method was suitable for multi-element tissue analysis (Zasoski & Burae, 1977).

2.5.3. Vitamin analysis

The total β-carotene as well as *trans* β-carotene content were analysed by the laboratory of the MRC in Cape Town. An aliquot of between 2.5 and 3 g of the homogenised sample was weighed and the carotenoids extracted with tetrahydrofuran:methanol (1:1, vol/vol), partitioned to petroleum ether and ß-carotene content

determined with High Performance Liquid Chromatography (HPLC) as described in Kimura and Rodriguez-Amaya and Low and Van Jaarsveld. It was analysed in duplicate by HPLC (SpectraSERIES; Thermo Separation Products, Fremont, CA) using a monomeric C18 column (Waters Spherisorb S3 DS2), mm, 4.6_150 mm. The mobile phase consisted of acetonitrile, methanol, and ethyl acetate containing 0.05% of TEA (triethylamine) used at a flow rate of 0.5 ml/min.by using a validated method established for the study. A β-carotene standard (synthetic, crystalline, Type II, product C-4582; Sigma Chemical Co, St Louis, MO) was purified by HPLC and an aliquot of the purified standard solution with a known concentration was used as the

external standard for quantification of β-carotene in the sample extract (Van Jaarsveld *et al.*, 2005; Faber *et al., 2010*).

Vitamin B_2 was analyzed at the ARC – Irene Analytical Services, a laboratory accredited by the South African National Accreditation System (SANAS). Between 2-3g of each sample were weighed into an Erlenmeyer flask and put into the auotoclave for 15 min. After autoclave extraction, samples were diluted to volume and analyzed with High Performance Liquid Chromatography (HPLC) using a fluorescence detector (Ex = 450nm, Em = 530nm) and a µBondapak C18 column (with guard column) with 70 % methanol as the mobile phase (Wimalasiri & Wills, 1985; Sims & Shoemaker, 1993). A quality control sample was also analysed together with the batch of samples and recorded on a control chart. The result of the control sample was within control limits therefore the results of this analysis can be accepted as reliable.

2.6. Statistical analysis

Nutrient data obtained from analysis were entered on a spreadsheet using Microsoft Excel (2000). Data was analyzed using the statistical program GenStat (2003). However as the data was limited to very few samples, the statistical data is not presented in this paper.

2.7. Quality assurance

The blank values for the mineral analysis was provided by the ARC – Institute for Soil, Climate and Water. ß - Carotene was determined in duplicate and a 5-point standard curve was constructed in triplicate. Vitamin B_2 was determined in duplicate with a HPLC and fluorescence detection. The method is SANAS accredited. A four point calibration curve is used in the quantification. A control sample is analyzed with every batch of samples to ensure reliability of results.

Inter-lab comparison tests using the leafy vegetables in the study as test samples, were performed for protein, fat and ash between the ARC-Irene Analytical Services and the University of Pretoria. The confidence intervals between the laboratories were 98.18 % for protein, 69.01 % for fat and 103.24 % for ash content.

The protein and ash were in the range of 95% to 105 % which is an acceptable variation. The inter-lab comparison test therefore verify the method used. Although the fat (69.01%) fell below the range of 95 – 105% no significance can be attached to these results, due to the low fat content of the leafy vegetables.

3. RESULTS AND DISCUSSION

The moisture content of the raw leaves ranged between 80.99 % to 89.91 % (Table 2). Raw misbredie was found to have the highest moisture content (89.91 %) following by cowpea leaves (87.56 %) and pumpkin leaves (87.33 %). Raw cat's whiskers (84.17 %) and wild jute (80.99 %) had the lowest moisture contents. The moisture content obtained in the leafy vegetables was close to the values previously reported (Uusiku et al., 2010). The review by Uusiku *et al.* (2010), documented that the moisture content of pumpkin leaves is 93 %.Depending on cultural preferences either young or mature leaves are harvested. Mature pumpkin leaves (*Curcubita maxima)* were harvested for the analysis during this study while the young leaves are usually harvested in other studies (van Zijl, 2002). The maturity of the pumpkin leaves harvested could have an influence on the moisture content (Bassey *et al.,* 2001). The leaves as well as the petiole of cat's whiskers was harvested which decreased the total moisture content.

Studies have shown that these leaves are usually consumed cooked (Jansen van Rensburg *et al.,* 2004). The cooked values were therefore of importance. The moisture content of the cooked leaves (Table 2) ranged between 82.33 % and 90.86 %. This is also close to previously reported values. Variation could be due to different post-harvest treatments used in the other studies (Oboh, 2005).

The protein content in the raw leaves was highest in cat's whiskers (5.68 %) and lowest in misbredie (3.49 %). It was also the highest in cooked cat's whiskers (4.45 %), but the lowest in cowpea leaves (3.03 %). According to Uusiki *et al.* (2010), cowpea leaves had a protein content of 5%, while pumpkin leaves had a lower protein content of 3 %. The composition table of selected foods from West Africa (Stadlmayr et al., 2010), also reported the protein content of cowpea leaves to be higher with a value of 4.7 %. The petiole which forms part of the edible portion might increase the protein content. High nitrogen levels in the soil, due to cattle and chicken manure, could also result in plants with higher protein content (Oboh, 2005). Traditionally, in some communities it is given to mothers after giving birth and during breastfeeding (Chewya & Mnzava, 1997).

The proximate composition and energy content can also be observed in Table 2. It was found that there is an increase in moisture content in the cooked leaves. Similar results were found by Onyeike *et al.* (2003). The percentage crude fat, crude protein as well as ash decreased in the cooked leaves as predicted by Onyeike *et al.* (2003) and Oboh (2005). Misbredie and pumpkin leaves showed an increase in protein and ash content respectively..

The Index of Nutritional Quality (INQ) is a method of quantitative and qualitative analysis of single foods, meals, and diets which has special significance in assessing nutritional problems. The INQ shows the relationship between the amounts of nutrient provided compared to the recommended daily allowances for that specific nutrient. The amount of energy it provides in terms of the average energy intake was also taken into consideration. INQ may be calculated by computer and printed as bar graphs and tabular data. The number of nutrients and the nutrient standards used for analysis are flexible parameters which may be varied for each clinical situation (Sorenson, et al.). The index of nutritional quality (INQ) can be seen in Figure 1. The daily recommended values were obtained from Wardlaw, Hampl and Disilvestro (2004). A product with an INQ of two to six was seen as a good source while values above six were an excellent source (Venom, s.a.). In Figure 1 it can be seen that all the leafy vegetables were good sources of protein. Community members reportedly use dried leafy vegetables in winter as a protein substitute (Vorster, Jansen van Rensburg, Van Zijl, 2002). This can be useful in populations suffering from protein energy malnutrition.The mineral content of the five dark green leafy vegetables can be seen in Table 3. Raw leaves of misbredie, cat's whiskers and wild jute contained the highest concentration ofiron (16.2 mg/100g), zinc (1.0 mg/100g) as well as phosphorus (146.4 mg/100g) and calcium (584.5 mg/100g) respectively. Many of the mineral values are notable higher than values reported in the review by Uusiki *et al.* (2010), who, for example, found that misbredie had an iron content of between 0.3 and 3.8 mg/100g, while cat's whiskers had a zinc content of between 0.6 and 0.8 mg/100g. No values of the phosphorus or calcium content for wild jute was reported in the review.

Comparing the nutrient content of the cooked leaves, pumpkin leaves had the highest iron content (15.7 mg/100g) while wild jute contained the highest zinc (1.3 mg/100g), calcium (586.2 mg/100g) as well as phosphorus (138.3 mg/100g) levels. Raw cat's whiskers (146.4 mg/100g) had the highest magnesium content, followed by raw pumpkin leaves (142.3 mg/100g) and misbredie (141.2 mg/100g). The magnesium values for raw misbredie correlated well with the findings in the review of Uusiki *et al.* (2010), while the reported values for magnesium were 44 to 76 mg/100g in raw cat's whiskers, and 38 mg/100g in raw pumpkin leaves.

Cooked pumpkin leaves (111.3 mg/100g) and cooked misbredie (104.9 mg/100g) had higher magnesium levels than cooked cowpea leaves (34.5 mg/100g), cat's whiskers (91.45 mg/100g) and wild jute (74.15 mg/100g). Cowpea leaves contained the lowest concentration of all the selected minerals.

As expected, cooking of the leaves decreased the content of iron, zinc, magnesium and calcium (divalent ions). A decrease was observed in the magnesium content of the raw (146.4 mg/100g)

and cooked (91.45 mg/100g) cat's whiskers. Due to the fact that the petioles and the leaves of cat's whiskers were cooked, more cooking water and cooking time were needed to cook the leaves till tender. More magnesium could therefore leach out in the cooking water during the cooking process than in the other samples. (Vorster, Jansen van Rensburg, Van Zijl, 2002).

) Cooked wild jute had higher iron and zinc levels in the cooked than the raw leaves. Cooked misbredie (272.2 mg/100g) contained higher calcium levels than the raw misbredie (232.3 mg/100g).

The mineral content of the raw leaves were in general higher than previous reported values (Uusiki *et al.,* 2010). The higher mineral content in the leaves could be due to the fact that chicken and cattle manure was used as fertilizers in the soil. Animal manure contains significant amounts of nutrients (nitrogen, phosphorus, potassium, magnesium, copper and zinc) which are easily absorbed by plants (Eneji, Honna & Yamamoto, 2001). The starch, percentage nitrogen, phosphorus and potassium increase in leaves when cattle and chicken manure are used (Abou-Hussein *et al.*, s.a.).

The five dark green leafy vegetables showed higher levels of beta-carotene and lower levels of vitamin B_2 for both raw and cooked leaves comparing to existing values (Uusiki *et al.*, 2010).

In Table 4 the concentration of selected vitamins in raw and cooked leaves can be seen. Both raw and cooked pumpkin leaves had the highest levels of Vitamin B_2 of 0.12 and 0.08 mg per 100 gram edible portion respectively.

The total beta-carotene levels were higher in the cooked leaves than in the raw leaves. This correlates with results from Faber *et al.,* (2010). The opposite was found in an experiment done by Gayathri *et al.,* (2004). They found that boiling resulted in the greatest loss of beta-carotene in *Amaranthus* (misbredie) specie. Processed samples also have greater extractability of carotenoids which could explain the higher beta-carotene levels in the cooked samples (Rodriguez-Amaya, 2002). This was not applicable to pumpkin leaves in which the beta-carotene decreased during the cooking process. That could be due to oxidative destruction of beta-carotene due to the fact that the pumpkin leaves were chopped before they were cooked. The increase in surface area could promote the oxidation of beta-carotene. As expected the percentage trans beta-carotene was lower in the cooked than in the raw leaves (Table 4). During the cooking procedure some of the trans beta carotene could have been converted to cis isomers

or other oxidative products (Lee *et al.*,1989; Nyambaka & Ryley, 1996; Rock et al., 1998). Although only trans beta carotene is potentially converted to retinol in the enterocyte (Faulks & Southon, 2004) the cooked leaves' beta-carotene are three times more bioavailable than the raw leaves (Rock *et al.,* 1998).

Riboflavin (vitamin B_2) are one of the most stable vitamins but are light sensitive (Coultate, 2002; 269). There was a decrease in vitamin B_2 levels in the cooked compared to the raw values (Table 4).

4. CONCLUSION

Plant material was sampled at only one location and a limited amount of material was sampled. This limited the possible application of these data to a broader population of these plants. Food samples are typically heterogeneous and, as a result, a bigger sample size is usually needed to obtain a representative sample (Rodriguez-Amaya, 1999). More than one random sample must be collected during the growing season of the food in question for analysis. Another limitation is a lack of analytical uncertainty. This is particularly a limitation when it comes to evaluating and comparing the nutrient content of indigenous foods. Attention must be given to these points in future studies of this nature.

Although limitations exist, the nutrient analyses of the traditional South African dark green leafy vegetables revealed that it is a good source of protein, minerals (iron, calcium, phosphorus and magnesium) and β-carotene. Cooking had an effect on the nutrient content. The moisture content increased in the cooking process while the proximate as well as the mineral concentrations decreased. It was found that the β-carotene levels were higher in the cooked than in the raw leaves.

Pumpkin leaves*,* cat's whiskersand misbredie had a higher index of nutritional quality based on protein than wild jute and cowpea leaves*.* All the leafy vegetables were nutrient dense for calcium, phosphorus and magnesium. It was also found that the leafy vegetables were nutrient dense for total β-carotene as well as *trans* β-carotene. The consumption of these leafy vegetables should therefore be encouraged. Due to the high nutrient content of these five dark green leafy vegetables, it could be promoted as a crop in SA and other developing countries to assist in promoting biodiversity and combating malnutrition.

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5. ACKNOWLEDGEMENT

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a

Curcubita maxima

Vigna unguiculata

Crochorus olitorius

Cleome gynandra

Amaranthus cruentus

CHO
Fat
Protein

0.00   1.00   2.00   3.00   4.00   5.00

Index of Nutritional Quality

b

Curcubita maxima

Vigna unguiculata

Crochorus olitorius

Cleome gynandra

Amaranthus cruentus

CHO
Fat
Protein

0.00   1.00   2.00   3.00   4.00   5.00
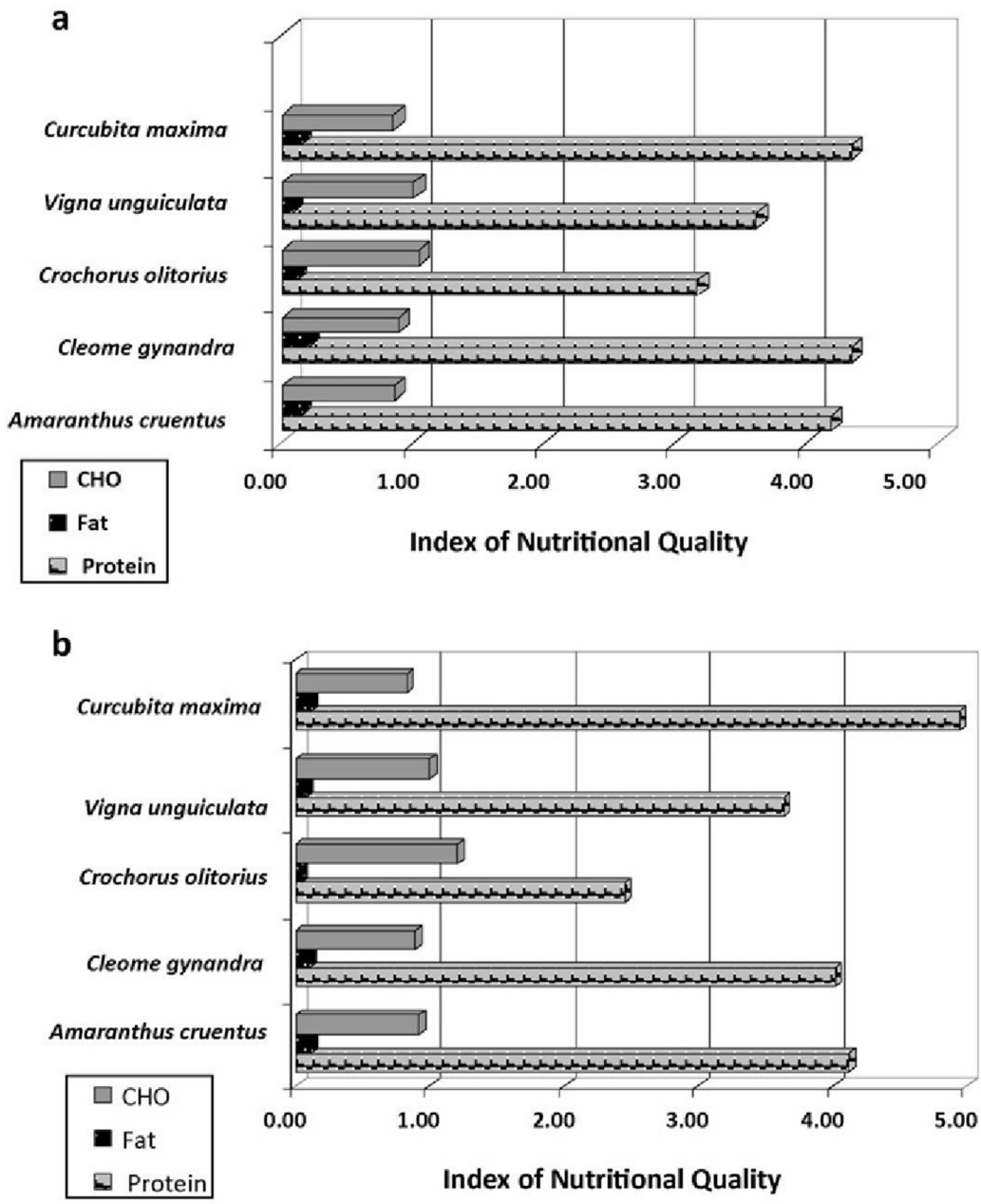
Index of Nutritional Quality

Fig. 1. Index of Nutritional Quality (INQ) of (a) raw and (b) cooked dark green leafy vegetables.

Table 1
Cooking procedure followed for dark green leafy vegetables.

Plant	Pretreatment	Cooking method	Leaves (g)	Amount of water (mL)	Covered/ uncovered	Cooking Time (min)
Amaranthus tricolor (misbredie)	Wash whole leaves	Add leaves to boiling water	119	350	Covered	15
Cucurbita maxima (pumpkin leaves)	Wash whole leaves, chop	Add leaves to boiling water	511	500	Covered	15
Cleome gynandra (cat's whiskers)	Wash leaves and petioles	Add leaves to boiling water	460	500	Covered	23
Vigna unguiculata (cowpea leaves)	Harvest leaves - place one day in sun before cooking	Add leaves to boiling water	380	700	Covered	40
Corchorus tridens (wild jute)	Wash leaves	Add leaves to boiling water	200	625	Covered	35

Table 2
Proximate composition and energy content of selected raw and cooked leafy vegetables per 100 gram edible portion.

Species	Raw/cooked	n	Moisture (g)	n	Protein (g)	n	Fat (g)	n	Ash (g)	Energy (calculated) (kJ)
Amaranthus tricolor (misbredie)	Raw	6	89.9 (1.12)	5	3.49 (0.03)	5	0.15 (0.02)	5	2.12 (0.09)	140
	Cooked	6	90.0 (1.12	3	3.51 (0.04)	3	0.13 (0.03)	2	1.65 (0.14)	143
Cucurbita maxima (pumpkin leaves)	Raw	6	87.3 (1.12)	3	4.24 (0.04)	3	0.12 (0.03)	3	3.23 (0.11)	164
	Cooked	6	89.1 (1.12)	2	3.71 (0.05)	2	0.12 (0.03)	2	3.35 (014)	126
Vigna unguiculata (cowpea leaves)	Raw	6	87.6 (1.12)	3	4.07 (0.04)	3	0.11 (0.03)	3	1.42 (0.11)	189
	Cooked	6	90.9 (1.12)	2	3.03 (0.05)	2	0.09 (0.03)	2	1.03 (0.14)	140.
Cleome gynandra (cat's whiskers)	Raw	6	84.2 (1.12)	4	5.68 (0.04)	4	0.36 (0.02)	4	2.77 (0.10)	220.
	Cooked	6	87.5 (1.12)	3	4.45 (0.04)	3	0.15 (0.03)	3	1.95 (0.11)	186
Corchorus tridens (wild jute)	Raw	6	81.0 (1.12)	5	5.19 (0.03)	5	0.25 (0.02)	5	3.00 (0.09)	275
	Cooked	6	82.3 (1.12)	4	3.82 (0.04)	4	0.09 (0.02)	4	2.72 (0.10)	262

Values are averages of analytical replicates.
Standard error of means indicated in brackets.

Table 3
Concentrations[a] of selected minerals (mg/100 g edible portion) in raw and cooked dark green leafy vegetables.

Species	Raw/Cooked	Iron (mg)	Zinc (mg)	Magnesium (mg)	Calcium (mg)	Phosphorus (mg)
Amaranthus tricolor (misbredie)	Raw	16.2	0.8	141	232	70.6
	Cooked	8.5	0.7	105	272	64.9
Cucurbita maxima (pumpkin leaves)	Raw	15.9	0.9	142	383	119
	Cooked	15.7	0.7	111	350	102
Vigna unguiculata (cowpea leaves)	Raw	3.9	0.5	54.7	221	80.1
	Cooked	3	0.5	34.5	151	56.7
Cleome gynandra (cat's whiskers)	Raw	14.3	1.0	146	393	147
	Cooked	14.5	1.0	91.5	265	110
Corchorus tridens (wild jute)	Raw	6.3	0.8	80.9	585	136
	Cooked	6.8	1.3	74.2	586	138

[a] Values are averages of duplicate analysis.

Table 4
Concentration[a] of beta-carotene and vitamin B_2 in raw and cooked dark green leafy vegetables (per 100 gram edible portion).

Species	Raw/Cooked	Total ß-carotene (μg)	*Trans* ß-carotene (μg)	% *Trans* of total ß-carotene (μg)	Vitamin B_2 (mg)
Amaranthus tricolor (misbredie)	Raw	1601	1214	75.8	0.03
	Cooked	2343	1701	72.6	0.01
Cucurbita maxima (pumpkin leaves)	Raw	1695	1300	76.7	0.12
	Cooked	796	589	74.9	0.08
Vigna unguiculata (cowpea leaves)	Raw	2249	1748	77.7	0.05
	Cooked	2614	1727	66.1	0.04
Cleome gynandra (cat's whiskers)	Raw	4117	2949	71.6	0.08
	Cooked	6047	2332	71.6	0.06
Corchorus tridens (wild jute)	Raw	3663	2748	75.0	0.07
	Cooked	6135	4384	71.5	0.04

[a] Values are averages of duplicate analytical replicates.