ELSEVIER

Journal of Food Composition and Analysis 20 (2007) 430–435

JOURNAL OF FOOD COMPOSITION AND ANALYSIS

www.elsevier.com/locate/jfca

Short Communication

Preliminary assessment of nutritional value of traditional leafy vegetables in KwaZulu-Natal, South Africa

B. Odhav[a,*], S. Beekrum[b], Us Akula[a], H. Baijnath[c]

[a]*Department of Biotechnology, ML Sultan Campus, Durban Institute of Technology, P.O. Box 1334, Durban 4000, South Africa*
[b]*Department of Food Technology, Steve Biko Campus, Durban Institute of Technology, P.O. Box 1334, Durban 4000, South Africa*
[c]*Department of Botany, School of Botany and Zoology, Westville Campus, University of KwaZulu-Natal, South Africa*

Received 17 November 2005; received in revised form 20 April 2006; accepted 27 April 2006

Abstract

In this report, we present preliminary nutritional data for traditional leafy vegetables collected in Kwa Zulu-Natal, South Africa, including their content of mineral elements (Ca, P, Na, Zn, Mg, Mn and Fe) and antioxidant levels. Twenty vegetables were studied: *Amaranthus dubius*, *Amaranthus hybridus*, *Amaranthus spinosus*, *Asystasia gangetica*, *Bidens pilosa*, *Centella asiatica*, *Ceratotheca triloba*, *Chenopodium album*, *Cleome monophylla*, *Cucumis metuliferus*, *Emex australis*, *Galinsoga parviflora*, *Justicia flava*, *Momordica balsamina*, *Oxygonum sinuatum*, *Physalis viscosa*, *Portulaca oleracea*, *Senna occidentalis*, *Solanum nodiflorum* and *Wahlenbergia undulata*. The results of this study provide evidence that these local traditional vegetables, which do not require formal cultivation, could be important contributors to improving the nutritional content of rural and urban people. From this study, it was determined that twelve leafy vegetables, namely *A. dubius*, *A. gangetica*, *A. hybridus*, *A. spinosus*, *C. metuliferus*, *C. monophylla*, *C. triloba*, *G. parviflora*, *J. flava*, *M. balsamina*, *P. viscosa* and *W. undulata* provide mineral concentrations exceeding 1% of plant dry weight and are much higher than typical mineral concentrations in conventional edible leafy vegetables; they are thus recommended for future commercial cultivation. High levels of antioxidant activity (96%) were noticed in *J. flava* and *P. oleraceae*.

Keywords: Nutritional value; Mineral content; Antioxidants; Food supplement; African leafy vegetables

1. Introduction

South Africa is a country with great cultural diversity and biodiversity, with many people still using a wide variety of plants in their daily lives for food, water, shelter, fuel, medicine and other necessities of life (Van Wyk and Gericke, 2000). These plants, often referred to as traditional vegetables, account for 10% of the world's higher plants. However, they are under-utilised in favour of introduced non-native vegetables (Rubaihayo, 1992).The availability of indigenous vegetables has declined drastically because of excessive cultivation of field crops, which includes chemical elimination of wild vegetables and habitat change. There is also growing ignorance among young people about the existence of these nutritionally rich food plants.

This decline in the use of indigenous vegetables by many rural communities has resulted in poor diets and increased incidence of nutritional deficiency disorders and diseases in many parts of Africa (Kwapata and Maliro, 1995). The World Health Organization (1982) has reported that chronic under-nutrition affects some 200 million people, or 42% of the population, in sub-Saharan Africa. Traditional vegetables represent inexpensive but high-quality nutrition sources for the poor segment of the population, especially where malnutrition is widespread. Traditional vegetables grow wild and are readily available in the field as they do not require any formal cultivation. Communities in Africa have a long history of using traditional leafy vegetables to supplement their diets (Chweya and Eyzaguirre, 1999). In addition to some earlier works on this topic (Fox and Norwood Young,

*Corresponding author. Tel.: +27 31 3085321; fax: +27 31 3085351.
E-mail address: odhavb@dit.ac.za (B. Odhav).

0889-1575/$ - see front matter © 2006 Elsevier Inc. All rights reserved.
doi:10.1016/j.jfca.2006.04.015

1982; Tredgold, 1986), several recent publications (Nesamvuni et al., 2001; Steyn et al., 2001; Jansen van Rensburg et al., 2004) have stressed the nutritional value of traditional and indigenous leafy vegetables. However, the use of traditional and indigenous leafy vegetables by local people is still a relatively under-researched discipline in South Africa. Knowledge of indigenous plant use needs urgent scientific investigation and documentation before it is irretrievably lost to future generations (Guarino, 1997).

The purpose of this study was to conduct a preliminary assessment of the nutritive value of a range of traditional leafy vegetables. These data should be a starting point for a valuable knowledge resource, allowing better food selection and consequent improvement in nutritional status of the diet of local populations in South Africa.

2. Materials and methods

2.1. Samples

Nutritional analyses (moisture, protein, fat, fibre, ash and minerals) were conducted using the leaves of 20 raw traditional vegetables (Table 1). Approximately, 10 kg of leafy material were selected from several plants of each variety. Local floristic keys were used for determining the species. Data on different species and the Zulu names have been sourced from publications on the flora of South Africa (Hutchings, 1996). Voucher specimens are housed in the Ward Herbarium, University of Kwazulu-Natal, Westville campus, South Africa (see Table 1, Hutchings, 1996).

The plants were processed on the same day that they were harvested. Healthy, green, mature leaves were removed from the stems and washed thoroughly with distilled water until no foreign material remained, and air-dried at room temperature for 2 h. Moisture, protein, fat, fiber and ash analyses were conducted on fresh leaves that were ground using a mill. Samples used for mineral analyses were washed using double deionized water and dried in an air oven for 6 h at 60 °C, homogenized using a mill. The dried samples were stored in a dark cupboard in capped bottles in desiccators and used within 1 month after harvesting. All analyses were conducted in duplicate and results were based on fresh weight per 100 g of sample.

2.2. Chemical analysis

For the chemical analysis, aliquots were made from 0.5 g of fresh weight from each sample analysed. Two replicates were made from separate aliquots. Energy was calculated (kcal/100 g fresh weight) using the Atwater system as described by the World Health Organization (1985) by multiplying the values obtained for protein, carbohydrates and fat by 4.00, 3.75 and 9.00, respectively; the results are expressed in kcal.

Moisture, ash, crude protein, fat and dietary fiber were analysed by the methods described in AOAC (1990). Moisture was determined using the drying oven method, by drying a representative 5 g sample in an oven at 105 °C for 3 h. Ash content was determined by the incineration of a sample (4 g) in a muffle furnace at 600 °C for 6 h until the ash turned white.

Crude protein was estimated by the Kjeldahl method. Total protein was calculated by multiplying the evaluated nitrogen by 6.25. Fat was determined by petroleum ether extraction in a Soxhlet apparatus. A representative 3 g of sample was extracted for 6 h. Dietary fibre was analysed by an enzymatic gravimetric method using the Tecator

Table 1
Species, habitat and consumption of leafy vegetables in greater Durban area of Kwazulu-Natal, South Africa

Scientific name	Family	English name	Zulu name	Habitat	Typical consumption
Amaranthus dubius	Amaranthaceae	Wild spinach	Imbuya	Cultivated land	Regularly
Amaranthus hybridus	Amaranthaceae	Cockscomb	Imbuya	Disturbed land	Regularly
Amaranthus spinosus	Amaranthaceae	Spiny pigweed	Imbuya	Roadside weed	Regularly
Asystasia gangetica	Acanthaceae	Hunter's spinach	Isihobo	Disturbed land	During famine
Bidens pilosa	Asteraceae	Black jack	Amalenjane	Disturbed land	Regularly
Centella asiatica	Apiaceae	Marsh pennywort	Icudwane	Sandy shade	During famine
Ceratotheca triloba	Pedaliaceae	Wild foxglove	Udonqabathwa	Cultivated land	Regularly
Chenopodium album	Chenopodiaceae	Fat hen	Imbikilicane	Cultivated land	Regularly
Cleome monophylla	Capparaceae	Spindle-pod	Isiwisa	Cultivated land	Regularly
Cucumis metuliferus	Cucurbitaceae	Jelly melon	Uhufafa	Roadside dump	During famine
Emex australis	Polygonaceae	Devil's thorn	Inkunzane	Roadside weed	Occasionally
Galinsoga parviflora	Asteraceae	Gallant soldier	Ushukeyana	Cultivated land	Regularly
Justicia flava	Acanthaceae	Yellow justicia	Ipela	Grass land	Occasionally
Momordica balsamina	Cucurbitaceae	Balsam apple	Umkaka	Disturbed land	Regularly
Oxygonum sinuatum	Polygonaceae	Stars talk	Untabane	Roadside weed	During famine
Physalis viscosa	Solanaceae	Sticky gooseberry	Uqadolo	Disturbed land	During famine
Portulaca oleracea	Portulacaceae	Purslane	Madilika	Cultivated land	Regularly
Senna occidentalis	Fabaceae	Coffee senna	Isinyembane	Roadside weed	During famine
Solanum nodiflorum	Solanaceae	Black nightshade	Umsobosobo	Cultivated land	Regularly
Wahlenbergia undulata	Campanulaceae	Giant bell flower	Ushwaqa	Grass land	During famine

Fibertec E System (Foss Tecator, Sweden). Carbohydrates (g/100 g) were estimated by using a difference method described by FAO (1985), by subtracting the sum of the per cent of protein, moisture, fat and ash from 100.

Mineral metallic elements (calcium, copper, iron, magnesium, manganese, zinc, sodium and phosphorus[1]) determined in homogenised samples were digested in a microwave digester. Three replicate aliquots (approximately 0.5 g) from each of the homogenized plant specimens were weighed into Teflon vessels to which 3 mL concentrated nitric acid and 1 mL concentrated hydrogen peroxide were added. Each vessel was closed with its Teflon cover and adapter then tightened with a spring disc. Vessels were positioned on the rotor and were secured by placing a circular safety band around them. The rotor was placed onto its base and each vessel was tightened using a torque wrench. The microwave oven and the fume extractor were switched on and the rotor was transferred to microwave oven. The digested contents from the vessels were transferred into 50 mL flasks and the volume was made up using double deionized water (Milestone Microwave Lab Systems, 1999). Concentrations were determined with an inductively coupled plasma (ICP) Perkin–Elmer spectrometer. Samples of respective mineral solutions were quantified against standard solutions of known concentration that were analysed concurrently (Perkin–Elmer, 1996).

2.3. Antioxidant assays

Antioxidant assays were carried out using the 2,2-diphenyl-1-pycril hydrazyl (DPPH) photometric assay outlined by Choi (2002). About 1 mL of 0.3 mM DPPH solution in ethanol was added to 2.5 mL (100 mg/mL) of sample solution (1 g of fresh leaves were thoroughly ground in 10 mL of methanol, filtered using whatman No. 1 filter paper; 2.5 mL of the filtrate was used) and was allowed to react for 30 min at room temperature. The absorbance values were measured with a Varian Cary 1E UV visible spectraphotometer (Varian Inc., Palo-Alto, CA, USA) set at 518 nm. About 1 mM Rutin hydrate (95%) HPLC grade (Sigma–Aldrich Inc., St. Louis, USA) in 99.5% absolute Ethanol (Merck chemicals, Pyt. Ltd., South Africa) was used as the standard and absolute ethanol was used as the negative control. Each test was carried out in duplicate and were prepared each time from fresh leaves including extraction using methanol and the average absorbance values were converted to percentage antioxidant activity using the following equation:

$$\text{Scavenging capacity \%} = 100 - [(\text{Abs of sample} - \text{Abs of blank}) \times 100/\text{Ab of positive control}].$$

[1]Note that potassium was not measured in these preliminary experiments; this mineral remains to be measured in these 20 vegetables.

3. Results

3.1. Proximate composition

The proximate composition of the vegetables examined in this study is presented (Table 2). *Senna occidentalis* and *Wahlenbergia undulata* yielded the highest energy levels of 84 kcal/100 g and 75 kcal/100 g, respectively. Results also indicate that 50% of the vegetables have significant energy values ranging from 50 to 70 kcal/100 g. All samples contained between 75% and 95% moisture. Protein content ranged from 2 g/100 g in *Ceratotheca triloba* to 7 g/100 g in *S. occidentalis*.

Three species, namely *Centella asiatica* (2.7 g/100 g), *S. occidentalis* (2.2 g/100 g) and *C. triloba* (2.2 g/100 g) stand out as being good sources of fat. The fat content of the remaining species ranged from a low of 0.2 g/100 g (*A. dubius*) to 0.8 g/100 g (*Physalis viscose*). There was a slight variation in the fibre content of the investigated vegetables species, ranging from 1.21 g/100 g (*Portulaca oleracea*) to 2.92 g/100 g (*Bidens pilosa*).

The leaves of *B. pilosa* are an excellent source of fibre (2.92 g/100 g), while the lowest quantity of fibre was found in the leaves of *P. oleracea* (1.21 g/100 g). Fifty per cent of the species contained fibre values ranging between 2 and 3 g/100 g. The ash content ranged from 1.71 g/100 g (*Galinsoga parviflora*) to 4.91 g/100 g (*Amaranthus hybridus*). The carbohydrate content of the leaf samples varied considerably, ranging from 1.16 g/100 g in *Amaranthus spinosus* to 12.8 g/100 g in *W. undulata*.

3.2. Mineral levels

Mean values for mineral content of nutritional importance are presented in Table 3. The species analysed in this study contained remarkably high amounts of calcium (>1000 mg/100 g), except for the leaves of *C. triloba* (705 mg/100 g) and *G. parviflora* (162 mg/100 g). The phosphorus content of the leaves varied greatly and ranged from 38 mg/100 g (*G. parviflora*) to 814 mg/100 g (*Asystasia gangetica*).

Noteworthy is the outstanding sodium concentration in the leaves of *Oxygonum sinuatum* (1460 mg/100 g) while *C. asiatica* (16 mg/100 g) contained the lowest amount. The highest quantity of copper (10 mg/100 g) was found in the leaves of *B. pilosa*. There was a narrow range of 2 mg/100 g to 4 mg/100 g for all the species analysed, with the exception of *Emex australis*, which contained a copper concentration of 1 mg/100 g. The richest source of zinc was found in *Chenopodium album* (109 mg/100 g) while the poorest source was *C. triloba* (3 mg/100 g). All the plants analysed were excellent sources of magnesium, ranging from 193 mg/100 g (*W. undulata*) to 1409 mg/100 g (*Justicia flava*). The manganese content of the leaves ranged from 2 mg/100 g in *P. viscosa* to a remarkable value of 82 mg/100 g in *A. dubius*. The leafy vegetables evaluated contain substantial quantities of iron and the leaves of

Table 2
Proximate composition of vegetables studied (per 100 g[a] fresh weight)

Vegetables	Energy (kcal)	Moisture (g)	Protein (g)	Fat (g)	Fibre (g)	Ash (g)	Carbohydrates (g) (estimated)
Amaranthus dubius	49	85	4	0.2	2.87	3.42	7.86
Amaranthus hybridus	53	83	**6**	0.5	2.81	4.91	6.09
Amaranthus spinosus	27	91	**4**	0.6	2.48	2.76	4.30
Asystasia gangetica	50	85	3	0.5	1.63	2.84	8.27
Bidens pilosa	39	88	**5**	0.6	**2.92**	2.82	3.72
Centella asiatica	52	88	3	**2.7**	1.92	2.54	3.81
Ceratotheca triloba	**62**	85	2	**2.1**	2.07	2.27	8.28
Chenopodium album	59	83	**5**	0.8	1.92	2.94	8.34
Cleome monophylla	39	88	**5**	0.7	2.14	3.01	3.40
Cucumis metuliferus	43	87	4	0.7	2.42	2.73	5.55
Emex australis	36	89	**5**	0.6	1.57	2.62	2.73
Galinsoga parviflora	41	89	4	0.5	1.24	1.74	5.29
Justicia flava	51	84	3	0.4	1.39	3.32	8.77
Momordica balsamina	53	85	**5**	0.5	2.75	2.07	6.82
Oxygonum sinuatum	25	92	3	0.5	1.68	2.16	2.85
Physalis viscose	**69**	81	**6**	0.8	1.97	2.25	9.81
Portulaca oleracea	23	93	3	0.3	1.21	1.86	2.65
Senna occidentalis	**84**	77	**7**	**2.2**	2.58	4.23	9.37
Solanum nodiflorum	55	85	3	0.6	2.42	2.24	9.03
Wahlenbergia undulata	**75**	80	**5**	0.3	1.33	2.05	**12.8**

Bold values represent a good source.
[a]100 g of leafy vegetables equals about 3 cups.

Table 3
Mineral content of vegetables studied (mg/100 g[a] dry weight)

Vegetables	Calcium	Phosphorus	Sodium	Manganese	Copper	Zinc	Magnesium	Iron
Amaranthus dubius	1686	487	347	**82**	3	56	**806**	25
Amaranthus hybridus	**2363**	604	427	24	2	18	**1317**	21
Amaranthus spinosus	**3931**	629	393	3	3	15	**1166**	32
Asystasia gangetica	**2566**	**814**	933	18	4	7	**961**	21
Bidens pilosa	1354	504	290	21	**10**	22	**658**	17
Centella asiatica	**2425**	327	16	23	7	20	**271**	18
Ceratotheca triloba	705	223	115	8	3	3	**428**	19
Chenopodium album	1490	797	683	27	4	**109**	**1239**	13
Cleome monophylla	**3203**	784	25	10	2	5	**371**	24
Cucumis metuliferus	**2974**	434	317	4	3	11	**1022**	20
Emex australis	160	290	332	31	1	20	**1018**	15
Galinsoga parviflora	162	38	36	44	3	14	**681**	27
Justicia flava	**2073**	292	581	8.4	6	11	**1409**	16
Momordica balsamina	**2688**	356	376	10	3	12	**613**	23
Oxygonum sinuatum	1474	473	**1460**	4	4	7	**521**	39
Physalis viscosa	1167	616	364	2	5	14	**535**	20
Portulaca oleracea	1361	333	148	24	3	34	**1037**	42
Senna occidentalis	**2230**	417	347	7	2	9	**854**	11
Solanum nigrum	**2067**	478	431	3	6	23	**277**	**85**
Wahlenbergia undulata	1305	308	374	7	2	41	**193**	19

Bold values represent a good source.
[a]100 g of leafy vegetables equals about 3 cups.

Solanum nodiflorum contained a significantly high level of 85 mg/100 g.

3.3. Antioxidant activity

A comparison of the antioxidant activity of the methanolic extracts of fresh leaves (100 mg/mL) along with rutin (Choi, 2002) is shown in Table 4. The values presented were relative values to rutin, a known flavonoid with 95.5% scavenging activity. High levels of antioxidant activity (96%) were noticed in *P. oleraceae* and *J. flava*.

4. Discussion

Although further sampling and additional analyses along with certified reference materials would be necessary

Table 4
Antioxidant activity of vegetables studied (% inhibited per 100 mg/mL of methanol extract)

Plant name	% inhibited
Rutin (+ control)	100
A. dubius	78
A. gangetica	84
A. hybridus	90
A. spinosus	88
B. pilosa	88
C. album	82
C. asiatica	88
C. monophylla	84
C. triloba	84
E. australis	78
G.parviflora	76
J. flava	**96**
M. balsaminia	**94**
O. sinuatum	92
P. oleracea	**96**
P. viscosa	82
S. nigrum	92
S. occidentalis	82

Bold values represent a good source of antioxidant activity.
Antioxident activity was expressed as % scavenging capacity of the methonolic plant extracts (100 mg/mL) made from the fresh leaves.
The activity obtained for flavanoid rutin was taken as 100% (positive control) and other values represented were relative activity compared to rutin.
Scavenging capacity (%) = 100–[(Abs of sample–Abs of blank) × 100/Abs of positive control].

to establish definitive values for nutrient composition, the results of this study potentially indicate that the plants studied are well endowed with essential nutrients required for human consumption. The leaves of *Momordica balsamina*, *A. spinosus*, *A. hybridus*, *Cleome monophylla*, *B. pilosa*, *C. album*, *P. viscosa*, *W. undulata*, *S. occidentalis and C. asiatica* contain significant amounts of protein. Furthermore, *P. viscosa*, *W. undulata*, *S. occidentalis*, and *C. asiatica* are regarded as famine foods by the African community and are typically only consumed when nothing else is available, yet these vegetables have high nutrient values and thus it may be desirable to introduce them into cultivation. These vegetables provide approximately 11% of the RDA for protein, and studies by Maundu et al. (1999) report higher protein content for *A. hybridus* and *S. nodiflorum*. Van Wyk (2005) reported the protein values for *C. album* (4.4%), *Amaranthus hybridus* (3.5%) and *G. parviflora* (3.29%). The protein content of the leafy vegetables in this study is higher than the protein content of commercial vegetables with the exception of certain legumes, as observed by Kruger et al. (1998) and Langenhoven et al. (1991).

The findings of the moisture, ash and fat content of most of the vegetables analysed in this study conform to the previously published literature for commercial and indigenous vegetables as reported by Maundu et al. (1999), Kruger et al. (1998) and Langenhoven et al. (1991), while fibre values for all the vegetables used in this study were lower than most of the leafy commercial vegetables compiled by Langenhoven et al. (1991), but similar to values for indigenous leafy vegetables reported by Maundu et al. (1999). Van Wyk (2005) reported the fat values for *G. parviflora* (2.06%), *C. album* and *A. hybridus* (0.3%).

All the leafy vegetables contain high levels of minerals, particularly *B. pilosa*, *C. album*, *S. nodiflorum*, *P. oleracea* and *E. australis*. The values obtained from this study in comparison to those available in the published literature showed much disagreement with those reported by Ogle and Grivetti (1985). However, there was some agreement in relation to mineral content as observed by Boukari et al. (2001) and Glew et al. (1997). Variations in the chemical composition of leafy vegetables, including the quantities of compounds that are useful and detrimental to humans, is influenced by farming practices and prevailing environmental conditions. Often sources of differences could be attributed to the age of plants at harvest, which affects their genetic composition (Nordeide et al., 1996).

Mineral concentrations exceed 1% of the plant dry weight, and generally are much higher than typical mineral concentrations in conventional edible leafy vegetables. These discoveries have raised the possibility that traditional leafy vegetables can be used as a concentrated form of essential mineral nutritional supplements. The form of the mineral in the leafy vegetables can also offer a potential benefit, since the bioavailability, or amount of mineral taken up and utilized by the body, can be modified depending on the mineral source. Although plant components such as phytates can interfere with mineral uptake by the body, leafy vegetables are generally considered to be superior sources of mineral supplements.

P. oleracea, *M. balsamina and O. sinuatum* were found to be efficient free radical scavengers (92–96% compared to rutin), whereas *E. australis*, *A. dubius and G. parviflora* have the least efficient free radical scavenging activity at the same concentration. These plants could thus potentially be exploited as sources of antioxidants.

Nutrient-rich foods are vital for proper growth both in adults and children. If we take into account the recommended dietary allowance (RDA) for minerals: calcium, 1000 mg/day; phosphorous, 800 mg/day; copper, 900 μg/day; zinc,10 mg/day; magnesium, 400 mg/day; manganese, 7 mg/day; and iron, 8 mg/day for adults (Food and Nutrition Board, Institute of Medicine, National Academies 2005), these traditional vegetables can provide 10% of the RDA. Health officers should promote the nutritional values of locally grown and consumed leafy vegetables among people, especially children, as this can contribute substantially to improving their diet.

The projections on sub-Saharan Africa for the next two decades, particularly as regards life expectancy and food security, are rather bleak. Practical interventions in health and nutrition are needed. Adding more leafy vegetables to the diet could potentially address some of these challenges, but further research will still be required in the following areas: the useful and toxic compounds in commonly

consumed traditional foods; education on dietary requirements; skills training in home gardening; income generation through large-scale cultivation; biotechnological techniques for improved yields; new methods for after-harvest preservation; and the potential value of value-added products.

Acknowledgements

We are particularly grateful to the South African and Netherlands Research programme on Alternatives in Development (SANPAD), and to the NRF for financial support.

References

AOAC, 1990. Official Methods of Analysis, 15th ed. Association of Official Analytical Chemists, Washington, DC.

Boukari, I., Shier, N.W., Xinia, E., Fernandez, R., Frisch, J., Watkins, B.A., Pawloski, L., Fly, A.D., 2001. Calcium analysis of selected western African foods. Journal of Food Composition and Analysis 14, 37–42.

Choi, C.W., 2002. Antioxidant activity and free radical scavenging capacity between Korean medicinal plants and flavonoids by assay guided comparison. Plant Science 163, 1161–1168.

Chweya, J.A., Eyzaguirre, P.B., 1999. The Biodiversity of Traditional Leafy Vegetables. IPGRI publication.

FAO, 1985. Food Composition Table for Use in Africa. Calculations to derive nutrients [online].Rome:FAO. Available from 〈http://www.fao.org/docrep/003/x6877e/X6877E20.htm〉.

Fox, F.W., Norwood Young, M.E., 1982. Food from the Veld: Edible Wild Plants of Southern Africa. Delta Books, South Africa.

Glew, R.H., Van der Jagt, C.L., Grivetti, L.E., Smith, G.C., Pastuszyn, A., Millson, M., 1997. Amino acid, fatty acid, and mineral composition of 24 indigenous plants of Burkina Faso. Journal of Food Composition and Analysis 10, 205–217.

Guarino, L., 1997. Traditional African vegetables. Promoting the conservation and use of underutilised and neglected crops. In: Guarino, L. (Ed.), Proceedings of the IPGRI International Workshop on Genetic Resources of Traditional Vegetables in Africa. IPGRI, Rome, Italy.

Hutchings, A., 1996. Zulu Medicinal Plants: An Inventory. University of Natal Press, Pietermaritzberg.

Jansen van Rensburg, W.S., Venter, S.L., Netshiluuhi, T.R., Van der Heever, E., Vorster, H.J., De Rorde, J.A., 2004. Role of indigenous leafy vegetables in combating hunger and malnutrition. South African Journal of Botany 70, 116–123.

Kruger, M., Sayed, N., Langenhoven, M., Holing, F., 1998. Composition of South African Foods: Vegetables and Fruit. Research Institute for Nutritional Diseases, South African Medical Research Council, South Africa, pp. 2–39.

Kwapata, B., Maliro, M.F., 1995. Indigenous vegetables in Malawi: germplasm collecting and improvement of production practices. In: Guarino, L. (Ed.), Traditional African Vegetables: Proceedings of the IPGRI International Workshop on Genetic Resources of Traditional Vegetables in Africa: Conservation and Use. IPGRI, Kenya, pp. 132–135.

Langenhoven, M.L., Kruger, M., Gouws, E., Faber, M., 1991. MRC Food Composition Tables, third ed. Research Institute for Nutritional Diseases, South African Medical Research Council, South Africa, pp. 100–125.

Maundu, P., Ngugi, G., Kabuye, C.H., 1999. Traditional Food Plants of Kenya. Kenya Resource Centre for Indigenous Knowledge (KENRIK), National Museum of Kenya, Nairobi.

Milestone Microwave Lab Systems, 1999. Basic Digestion Program with Milestone MDR Technology—Program 1. Milestone Microwave Lab Systems, USA, pp. 58–92.

Nesamvuni, C., Steyn, N.P., Potgieter, M.J., 2001. Nutritional value of wild, leafy plants consumed by the Vhavenda. South African Journal of Science 97, 51–54.

Nordeide, M.B., Hatloy, A., Folling, M., Lied, E., Oshaug, A., 1996. Nutrient composition and nutritional importance of green leaves and wild food resources in an agricultural district, Koutiala, in southern Mali. International Journal of Food Sciences and Nutrition 47, 455–478.

Ogle, B.M., Grivetti, L.E., 1985. Legacy of the Chameleon, edible wild plants in the kingdom of Swaziland, Southern Africa: a cultural, ecological, nutritional study. Part II. Ecology of Food and Nutrition 17, 1–30.

Perkin–Elmer, 1996. Plasma 400 Users Manual. Perkin Elmer, Germany, pp. 21–63.

Rubaihayo, E.B., 1992. The diversity and potential use of local vegetables in Uganda. In: Guarino, L. (Ed.), The First National Plant Genetic Resources Workshop: Conservation and Utilization. IPGRI, Kenya, pp. 109–114.

Steyn, N.P., Olivier, J., Wirter, P., Burger, S., Nesamvuni, C., 2001. A survey of wild, green, leafy vegetables and their potential in combating micronutrient deficiencies in rural populations. South African Journal of Science 97, 276–278.

Tredgold, M.H., 1986. Food Plants of Zimbabwe. Mambo Press, Gweru, Zimbabwe.

Van Wyk, B.-E., 2005. Food Plants of the World. Identification, Culinary Uses and Nutritional Value. Briza Publications, Pretoria, South Africa.

Van Wyk, B.-E., Gericke, N., 2000. People's Plants. Briza Publications, Pretoria, South Africa.

World Health Organization, 1982. Some of the common nutritional problems in South Africa.

World Health Organization, 1985. Energy and Protein Requirements. Report of a Joint FAO/WHO Ad Hoc Expert Committee. World Health Organization, Geneva.