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Vitamin A and mineral content of some common vegetables consumed in Swaziland

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ABSTRACT

Common Swazi leafy vegetables that are consumed by a significant number of the Swazi population include *Corchorius olitorus* [ligusha], *Momordica involucrata* [inkhakha], *Amaranthus spinosus* [imbuya], *Bidens pilosa* [chuchuza] and *Solanum nigrum* [umsobo]. Although they are part of the Swazi diet, no studies have been published so far on their nutritional composition. The objective of the project was to determine the levels of vitamin A, iron, calcium and zinc in these vegetables. The samples were collected from various areas throughout Swaziland. Vitamin A values were determined using reversed phase high performance liquid chromatography [HPLC] after saponification with potassium hydroxide, extraction with petroleum ether and dissolution in propan-2-ol. Iron, calcium and zinc values were determined using flame atomic absorption spectrometry [AAS]. Findings indicate that these vegetables are a good source of vitamin A with mean values for *Corchorius olitorus*, *Momordica involucrata*, *Amaranthus spinosus*, *Bidens pilosa* and *Solanum nigrum* being 959, 1194, 216, 1114 and 27 micrograms vitamin A per 100 g [All-trans retinal] respectively. All the samples analysed were good sources of iron, with Amaranthus spinosus having the highest concentration [41 mg/100 g] followed by *Corchorius olitorus* with 29 mg/100 while Momordica involucrata, Bidens pilosa and Solanum nigrum had the lowest content of iron [19 mg/100g]. The majority of the vegetables are good sources of calcium. The highest concentration of calcium [2683 mg/100 g] was found in Amaranthus spinosus while *Corchorius olitorus* and *Bidens pilosa* generally gave low calcium content [50 - 70 mg/100 g]. The highest zinc content [11.6 mg/100 g] was obtained from *Amaranthus spinosus* and the lowest [6.2 mg/100 g] from *Momordica involucrata*. The results obtained for common foodstuffs Vigna unguiculata, Vigna subterranea, *Cucurbitea moschata*, *Phaseolus vulgaris* and *Persea americana* agree with those of West [1987]. In general, micronutrient levels obtained from the five Swazi leafy vegetables are significantly higher than those from commonly consumed foodstuffs such as *Phaseolus vulgaris*. It is recommended that these leafy vegetables be eaten as a cheaper alternative to the expensive exotic foodstuffs consumed as sources of vitamin A, iron, calcium and zinc.

Key words: Micronutrients, Nutrition, Swazi leafy vegetables

INTRODUCTION

Micronutrient deficiency is a global problem which presently affects over two billion people worldwide, resulting in poor health, low worker productivity, high rates of mortality and morbidity [Kennedy et al., 2003]. Wild vegetables have been the mainstay of human diets for centuries and are receiving renewed attention from nutritionists, healthcare professionals, scientists, educationists, governments and the general public with the recognition that they could significantly contribute to alleviating hunger and malnutrition [Burlingame, 2000].

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Indigenous vegetables represent inexpensive but high-nutrition sources for the poor segment of the population, especially where malnutrition is widespread. Indigenous vegetables grow wild and are readily available in the field as they do not require any formal cultivation.

A large body of information exists on the micronutrient composition of wild vegetables, generally indicating higher mineral and vitamin contents than in cultivated vegetables.
Odhav *et al*. [2007] reported preliminary nutritional data for twenty [20] traditional leafy vegetables collected in Kwa Zulu Natal, South Africa and results provided evidence that these local traditional vegetables indicated good amounts of several micronutrients. From this study, it was determined that twelve leafy vegetables provide mineral concentrations much higher than typical mineral concentrations in conventional edible leafy vegetables. In another study, in which twenty five [25] wild vegetables were analysed for their mineral content in one district of Turkey, Turan *et al*. [2003] reported that the nitrogen, potassium, calcium, magnesium and protein contents of these vegetables were all higher than those of cultivated species, such as spinach, pepper, lettuce, and cabbage. However, concentrations of iron, manganese, zinc and copper were similar in both vegetable types.

Studies conducted by Ogle *et al*. [2001], Sundriyal and Sundriyal [2004] and Gupta *et al*. [2005] in Asia have also confirmed the importance of wild vegetables as sources of micronutrients. Other recent studies conducted on wild African vegetables by Vainio-Mattila [2000] in Tanzania, Nesamvuni *et al*. [2001], Steyn *et al*. [2001], Jansen van Rensburg *et al*. [2004] and Flyman and Afolayan [2006] in South Africa also underscored their significant contribution as sources of micronutrients.

In Swaziland, no studies have been published so far on nutritional composition of Swazi common foods. One of the key factors causing reduced micronutrient intake in Swaziland is the level of income which in-turn dictates the amount of money available for food production and/or purchase. The majority of people do not have enough money to buy food that will provide a balanced diet. This study attempted to provide basic data on the micronutrient content of ten such common foodstuffs in Swaziland.

LITERATURE REVIEW

Vitamin A

In Africa, vitamin A and iron deficiency is reported to affect about 1.3 million children under the age of five years. In Southern Africa 1 out of 3 children is vitamin A deficient [Ndossi and Kimboko, 1998]. The major vitamin and mineral deficiency diseases considered to be of public health concern in Swaziland include iodine deficiency [IDD], vitamin A deficiency [VDA] and Iron deficiency anaemia [IDA]. Few studies have been done on IDD, VDA and IDA prevalence in Swaziland. Todd [1993] and Lwenje *et al.*, [1998] carried out a study on the prevalence of the iodine deficiency in Swaziland. The Swaziland National Nutritional Council also undertook a national survey in 1995 on VDA. Blood samples were taken from children aged 6-71 months and the concentration of vitamin A was determined using the diagnostic criteria for vitamin A as given by Sickle *et al.* [1998]. From their results, they were able to conclude that fifty seven percent of mothers had inadequate concentrations of vitamin A in their milk to meet the metabolic needs of their babies while thirty one percent of mothers were classified as vitamin A deficient. These studies also revealed that forty six percent of babies were under marginal vitamin A and eight percent were vitamin A deficient. From the same studies it was established that twenty seven percent of stunted children lacked vitamin A.

Although required in minute amounts, vitamin A is necessary for the proper functioning of the body. Functions of vitamin A in the body, include; growth and repair of eyes for good vision; growth and repair of epithelial cells or the skin, lungs, developing teeth, inner ear, eye cornea, sex organs and ducts, gums, nose, cervix, and other areas; development of the embryo; development and maintenance of adrenal glands and synthesis of hormones such as the thyroid hormone; development of the body's immune system, growth and bone formation and antiviral activity [Sackheim and Lehman, 1998]. Severe deficiency leads to permanent blindness and increased severity of pneumonia and diarrhoea.

Measles infection increases the need for vitamin A [West, 1987]. Vitamin A is found in yellow fruits and vegetables such as peaches, apricots, sweet potatoes, carrots, tomatoes and in leafy green vegetables [Sackheim and Lehman, 1998].

Iron

Iron is an essential part of red blood cells [haemoglobin] and enzymes [cytochromes]. A well-known fact is that iron bonds oxygen and transports it to cells. Deficiency, which occurs especially in women and growing children, causes tiredness and lowered performance. Iron present in animal products is better absorbed than iron in plant foods [West, 1987]. Studies in Swaziland show that 30 to 50 % of people in the groups of infants, teenagers, pregnant women and elderly, suffer from iron deficiency [Ministry of Health Reports, Swaziland, 1995-1997]. The widely known disorder related to iron deficiency is anaemia whose symptoms are extreme fatigue, breathlessness and dizziness. Sources of iron are liver, legumes, cereals, beetroot and red meat. Iron deficiency is largely caused by: [i] an insufficient dietary intake [ii] poor bio-availability of iron consumed related to low consumption of absorption enhancers [such as meat, fresh fruit and vegetables], high consumption of absorption inhibitors [such as coffee, tea, phytates in some cereals, insoluble iron phosphates and other insoluble iron compounds formed with bile salts] and lack of hydrochloric acid [HCl] in stomach. Acids like ascorbic acid and HCl help reduce Fe^{3+} to highly absorbable Fe^{2+} ion [iii] blood loss due to menstruation and childbirth among women [iv] parasites such as hookworm [v] chronic and recurrent infections such as diarrhoeal diseases, malaria, sickle-cell and HIV/AIDS and [vi] low intake of complementary nutrients such as vitamin A, riboflavin and vitamin B_{12} [Mannar, 1998].

Calcium

Calcium is necessary for bone and teeth formation, blood clotting, muscle contraction and heart function. The known disorders from calcium deficiency include rickets, poor bone formation, delayed blood clotting and cramps. Major sources of calcium are milk, cheese, green vegetables, egg yolk, legumes and nuts [Sackheim and Lehman, 1998].

Zinc

Zinc, on the other hand promotes rapid healing of wounds and functions as an anti-oxidant. It is also a natural insect repellent and stimulates the transport of vitamin A from the liver to the skin, helping to protect body tissue from damage [Sackheim and Lehman, 1998]. Some sources of zinc include sea-foods, meats, liver, eggs, milk, whole grain cereals, citrus fruits, soya beans, sesame and peanut meals. Lack of zinc may result in the under-development of the foetus, lowered intelligence and even miscarriage. Zinc deficiency may also cause dwarfism in children and may result in youngsters of either sex suffering from retarded development of secondary sex characters which could eventually lead to infertility. Acquired zinc deficiency may cause mental confusion, eczema, baldness, catarrhal dysentery, hypoproteinemia, oedema and anorexia.

METHODOLOGY

Sampling

Ten samples were collected from various areas throughout Swaziland depending on the availability. A random sampling technique was adopted for all the foodstuffs. Foods were stored in a refrigerator and analysed within seven days of sampling. Table 1 shows the vegetable samples and the common foods that were analysed. Samples were identified using their siSwati, English and botanical names.

Table 1. Samples analysed and sampling areas

siSwati name	English name	Botanical name	Sampling area
Ligusha	Bush okra	*Corchorius olitorus*	Mahlanya
Inkhakha	Bitter gourd	*Momordica involucrata*	Nyakeni
Imbuya	Tassel flower	*Amaranthus spinosus*	Manzini
Chuchuza	Blackjack	*Bidens pilosa*	Manzini
Umsobo	Black nightshade	*Solanum nigrum*	Nyakeni
Tinhlumaya	Cow peas	*Vigna unguiculata*	Manzini
Tindlubu	Jugo bean	*Vigna subterranea*	Malindza
Tintsanga	Pumpkin seeds	*Cucubitea moschata*	Elwandle
Emabhontjisi	Green beans	*Phaseolus vulgaris*	Manzini
Likotapeni	Avocado	*Persea americana*	Mahlanya

Vitamin A analysis

Extraction

The samples were extracted according to the standard method [Analytical Methods Committee, 1985]. For the extraction of vitamin A, all operations were carried out away from natural light and strong influorescence light because vitamin A is sensitive to UV light and air. 50g of the sample [crushed or ground] was placed in a 500ml conical flask. 50ml potassium hydroxide solution, 200ml ethanol solution and 2ml sodium ascorbate solution were added into the flask and refluxed for 60 minutes in a boiling water bath. The flask was cooled to room temperature under tap water and then the contents of the flask were transferred into a cylinder. The saponification flask was rinsed with two 25ml portions ethanol and the rinsings were transferred into the cylinder. It was rinsed further with two 125ml portions light petroleum, and one portion distilled water. The cylinder was stoppered and shaken. The vitamin A was extracted into the light petroleum layer i.e. the organic layer, and transferred using an adjustable U-tube into a 500ml separating funnel. A total of 5 extractions were made. The combined light petroleum extract was washed with four 100ml portions of distilled water at first with gentle inversion only and then only gentle shaking to keep emulsions formation to a minimum. 5g of sodium sulphate was added and finally shaken well. The light petroleum extract was transferred into a flask suitable for evaporation, avoiding any transfer of the sodium sulphate. The sodium sulphate in the separator was rinsed with two 20ml portions of light petroleum and the rinsings transferred to the contents of the evaporation flask. The light petroleum extract was evaporated to dryness under vacuum at a temperature not exceeding 40 ^{o}C.

Determination

The residue was dissolved in minimal amount of propan-2-ol and transferred quantitatively into a 25ml calibrated flask. The evaporator was rinsed with 2-3 portions of propan-2-ol and the rinsing added to the calibrated flask. The flask was then filled to volume [the mark] with the propan-2-ol. Samples were analysed using the high performance liquid chromatograph [HPLC]. In cases where delay was unavoidable, the samples were stored under nitrogen in the refrigerator until analysed. The same experimental procedure was carried out for the standards from which the amount of vitamin A for the unknowns was extrapolated.

Micronutrient analysis

Digestion

0.5 g of each dry sample was weighed and placed in teflon microwave bombs. 20ml of a 1:1 mixture of 6 M HCl and 6 M HNO_3 was added, the bombs sealed, placed in a microwave and digested for a period of 2 minutes at powers of 270 W, 630 W and 630 W for iron, calcium and zinc respectively. After digestion, the contents were cooled to room temperature and then suction filtered using a membrane filter or ash-free Whatman filter paper to avoid adsorption of the ions to be analysed. The filtrate was transferred into a 50ml volumetric flask and diluted to the mark with distilled water.

Measurements
Analysis for iron, calcium and zinc was done using a flame atomic absorption spectrophotometer [AAS] or graphite furnace atomic absorption spectrophotometer [GFAAS] depending on the concentration of the samples. If the sample concentrations fell within the range 5-100 ppm, AAS was used and if the concentrations of the samples were within 10-100 ppb, GFAAS was used. Standards of iron, calcium and zinc were prepared making sure that the samples were bracketed on the calibration curve. All analyses were conducted in triplicate and results were based on dry weight per 100 g of sample.

RESULTS AND DISCUSSION

Table 2 summarises levels of the vitamin A, iron, calcium and zinc present in different foods. Table 3 shows the recommended daily intake percentage [RDI %] values per 100 g for the rich sources of vitamin A from common Swazi vegetables. The recommended dietary allowance [RDA] for vitamin A is 1000 μg [Blaauw, 1998]. It is clear from this data [Table 2 and Table 3] that green vegetables are a good source of vitamin A. The RDI values are comparable to those obtained from conventional high income foods. *Momordica involucrata* and *Bidens pilosa* have values of 1 194 and 1 114 μg per 100 g, respectively far above the recommended dietary allowance. These values are, however, far from the minimum toxic limit of Vitamin A of 1,500 μg which is regarded as chronic and much lower than the acute intoxication limit of 15,000 μg [Blaauw, 1998]. Acute intoxication occurring within hours or days is always accompanied by headache as a result of increased intracranial pressure. Other signs in children include anorexia, drowsiness, irritability and vomiting. The essential feature of chronic hypervitaminosis A is peeling of the skin and bone pains, especially in the long, tubular bones. Under extreme conditions of intoxication vitamin A may lead to liver cirrhosis. The Vitamin A level from these vegetables may be regarded as safe and the vegetables may be consumed without any negative effect.

Table 2. Nutritional values of vitamin A, iron, calcium and zinc for Swazi foods.

Foodstuff	Composition/100 g sample			
	Vitamin A [μg]	Iron [mg]	Calcium [mg]	Zinc [mg]
Corchorius olitorus	959.0 ± 27.7	28.8 ± 0.5	50.9 ± 2.3	6.9 ± 0.4
Momordica involucrata	1194.0 ± 30.9	19.0 ± 1.0	1024.2 ± 119.7	6.2 ± 0.2
Amaranthus spinosus	215.9 ± 11.0	41.0 ± 1.2	2683.3 ± 55.2	11.6 ± 0.6
Bidens pilosa	1113.6 ± 14.0	19.0 ± 0.8	68.0 ± 1.2	7.1 ± 0.5
Solanum nigrum	26.8 ± 4.6	19.0 ± 0.6	161.8 ± 1.8	10.6 ± 0.3
Vigna unguiculata	1.6 ± 0.3	11.0 ± 1.1	136.7 ± 3.9	8.9 ± 0.2
Vigna subterranea	0.6 ± 0.2	7.0 ± 0.8	36.0 ± 1.9	8.6 ± 0.3
Cucurbitea moschata	25.3 ± 1.2	4.2 ± 0.6	58.0 ± 3.1	2.6 ± 0.2
Phaseolus vulgaris	22.0 ± 2.1	1.8 ± 0.3	30.6 ± 2.1	ND
Persea americana	101.9 ± 3.2	3.6 ± 0.5	22.7 ± 3.0	ND

ND= Not done

The data for iron, calcium and zinc in Table 2 was obtained from flame atomic absorption spectrostrophotometry [AAS]. Table 3 shows the % RDI values per 100 g for some of the good sources of iron. The RDA for iron is 20 mg [Blaauw, 1998]. According to West's [1987] classification, most of the samples analysed in this research are good sources of iron. *Amaranthus spinosus* [41.0 mg/100 g; %

RDI = 205%] has the highest amount of iron. Although the iron content of many of these foodstuffs is generally high, one should also acknowledge factors affecting absorption. Mannar [1998] reported that one of the major causes of iron deficiency anaemia is poor bioavailability of absorption enhancers and a high consumption of inhibitors. Latham [1997] and Mannar [1998] observed that oxalates, phytates and nitrates are compounds that are contained in some of these indigenous plants and they affect the absorption of the micronutrients. Iron absorption is enhanced when blood levels are low [Blum, 1997]. Besides, iron absorption is enhanced when the vegetable is a good source of vitamin C.

Table 3. Recommended daily intake values for vitamin A, iron, calcium and zinc for the ten common Swazi foodstuffs

Vegetable	Per cent recommended daily intake/100 g sample			
	Vitamin A	Iron	Calcium	Zinc
Corchorius olitorus	96	144	5	46
Momordica involucrata	119	95	102	41
Amaranthus spinosus	22	205	268	77
Bidens pilosa	111	95	7	47
Solanum nigrum	3	90	16	71
Vigna unguiculata	0	55	14	59
Vigna subterranea	0	35	4	57
Cucurbitea moschata	3	21	6	17
Phaseolus vulgaris	2	9	3	ND
Persea americana	10	18	2	ND

ND = Not done

Table 3 shows the % RDI values per 100 g for the rich sources of calcium indigenous Swazi vegetables. The RDA for calcium is 1000 mg [Blaauw, 1998]. It is evident from the data that the majority of the samples considered are good sources of calcium with *Amaranthus spinosus* having the highest concentration of 2683 mg/100 g [268% RDI] sample dry weight. *Bidens pilosa, Momordica involucrata* and *Solanum nigrum* leaves gave values of 68, 1024 and 162 mg/100 g of sample corresponding to % RDI values of 7%, 102% and 16% respectively. *Corchorius olitorus* had the lowest content of 51 mg/100 g [5% RDI] of sample.

Table 3 gives the % RDI values per 100 g for zinc for the five common Swazi vegetables analysed. The RDA for zinc is 15 mg [Blaauw, 1998]. It is clear from the data that all the vegetables analysed are good sources of zinc with *Amaranthus spinosus* having the highest zinc content of 11.6 mg/100 g [77% RDI] closely followed by *Solanum nigrum* having a concentration of 10.6 mg/100 g [71% RDI]. *Corchorus olitorus* and *Bidens pilosa* had similar zinc levels of 6.9 and 7.1 mg/100 g reflecting %RDI values of 46% and 47% respectively. *Momordica involucrata* was the vegetable found to have the lowest zinc content of 6.2 mg/100 g yielding a % RDI value of 41%.

In general, micronutrient levels obtained from the five leafy vegetables studied are significantly higher than those from commonly consumed foodstuffs such as green beans [Table 3]. Therefore, these five indigenous vegetables are better sources of vitamin A, iron, calcium and zinc than some of the exotic foods.

VALIDATION OF DATA

Comparison with literature values and South African Bureau of Standards [SABS]

Table 4. Literature and South Africa Bureau Standards values

Sample	Micronutrient			
	Vitamin A [μg/100 g]	Iron [mg/100 g]	Calcium [mg/100 g]	Zinc [mg/100g]
Phaseolus vulgaris	20.0[a]	1.8[a]	22.0[a]	ND
Cucubitea moschata	30.0[a]	2.8[a]	57.0[a]	ND
Persea americana	90.0[a]	1.4[a]	19.0[a]	ND
Vignea unguiculata	2.0[a]	5.0[a]	80.0[a]	ND
Vignea subterranea	2.0[a]	12.0[a]	62.0[a]	ND
Momordica involucrata	1354[b]	26[b]	1349[b]	5[b]

ND – Not done
[a] West [1987]
[b] SABS [2002]

Data obtained in this study agree with those of West [1987] hence validation of West's results. The values obtained from this study also compare reasonably well with data obtained for the *Momordica involucrata* sample that was sent to the South African Bureau of Standards for analysis indicating the validity and applicability of the analytical protocols employed.

CONCLUSION AND RECOMMENDATIONS

It is clear from the data collected from this study that the indigenous Swazi vegetables provide vitamin A, iron, calcium and zinc and can be used as a cheaper and better alternative to the expensive sources of these micronutrients obtainable from town shops.

It is recommended that future research focuses on compilation of a complete composition table for local foods that will include all the major micronutrients. In future analysis should be done on cooked and stored samples to study the effect of cooking and storage on micronutrient content in these vegetables. Future research work must also concentrate on studying the extent to which the amount of micronutrients in the soil influences the availability of the micronutrients in the plant. In further study, it is recommended that the variation of the micronutrient content in the vegetables with age be determined as well as conduct bioavailability studies to determine amount of micronutrients available to the body at the cellular level.

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