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Nutritional Assessment of Chenopodium Album L. (Imbikicane) Young Shoots and Mature Plant-Leaves Consumed in the Eastern Cape Province of South Africa

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Abstract. The aim of this study was to determine the nutritional content of *Chenopodium album* young shoots and mature plant-leaves locally consumed in the Eastern Cape Province of South Africa. Young shoots and mature plant-leaves of *C. album* were analysed for proximate, vitamins and mineral composition according to AOAC standard analytical procedures. The mean values for carbohydrates, protein and fibre in the young shoots were 4.0, 32.2 and 37.0 (g/100g) while those for the mature plants were 7.0, 29.2 and 36.5 (g/100g) respectively. The calcium, potassium and magnesium content of young shoots was 12991, 45799 and 7982 (mg/1000g) while those for the mature plants were 18213.2, 49028.6 and 13821.5 (mg/1000g) respectively. Sodium was 48.8 and 68.0 (mg/100g) in young shoots and mature plants respectively. The microelements of Fe, Zn, Cu in the young shoots were 218.1, 26.2 and 14.0 (mg/1000g) while for the mature plant, they were 120.4, 23.0 and 9.1 (mg/1000g) respectively. Arsenic was 1.8mg/1000g, Sb and Sn measured <0.05mg/1000g and Cr measured 0.9mg/L in both young shoots and mature plants. The measurements for vitamin C were 5.6 and 5.2(mg/100g) while β-carotene measured 46 and 68 (μg/100g) in young shoots and mature plants respectively. Generally, the nutrient content of young shoots and mature plant-leaves were similar (P>0.05). These results indicate that *C. album* young shoots and mature plants could serve as potential sources of important dietary nutrients for the alleviation of problems associated with malnutrition in South Africa.

Keywords: African leafy vegetable; *Chenopodium album*; Vitamins; Minerals; Eastern cape; South Africa.

1. Introduction

The young shoots and leaves of *Chenopodium album* are consumed as vegetable in the rural areas of the Eastern Cape Province and other parts of South Africa [1]. The plant is commonly found along roadside paths, bushes and gardens where it grows as an erect annual herb producing angular stems, ribbed with longitudinal dark green or red streaks [2]. It is usually harvested by villagers and local dwellers and prepared with maize as porridge. It is referred to as lamb's quarters in English and *Imbikicane* in isiXhosa. It belongs to the family Chenopodiaceae [3].

Studies carried out in different parts of the world indicate that *C. album* is a rich source of nutrients, antioxidants and important dietary elements [1] and [4]. However, many indigenous leafy vegetables including *C. album* are neglected and despised in the urban areas of South Africa, despite their nutritional richness and potential to contribute to healthier diets in the country. This is a methodological deficiency given the high rate of vitamin A deficiency in South Africa, especially among children under 10 years of age [5].

C. album is known to be resistant to pests, diseases and thrives well in minimally nutritive soils [6]. The plant may therefore constitute a good source of genes for genetic improvement of other crop varieties.

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Scientific studies to determine the role of *C. album* and other indigenous leafy vegetables in the formulation of healthy diets in South Africa are imperative considering the high level of obesity in the country [7]. The underutilisation and marginalisation of these vegetables particularly in the urban areas may be attributed to the lack of scientific data on their nutritive properties. This study was therefore carried out to determine the nutritional composition of *C. album* young shoots and mature plants in an attempt to create awareness and generate information that could be useful in the formulation of healthier diets in South Africa.

2. Materials and Methods

2.1. Collection and Preparation of Plant Material

The young shoots and mature plant leaves of *C. album* were harvested from home gardens and along bush paths at Libode, 30 km from the Walter Sisulu University (WSU) main campus in October 2012. The plant samples were identified by Dr. Kathleen Immelman of the department of botany and vouchers deposited in the Kei herbarium (CN01). The plant material was washed, dried at 50 ˚C for 24 hours, powdered (ATO Mix, Cambridge) and stored in airtight containers at 5 ˚C for further analysis.

2.2. Proximate Analysis

Proximate determination which involved protein, fats, carbohydrates, dietary fibre, moisture, ash and energy was analysed in accordance with the Association of Official Analytical Chemists (AOAC) method as previously described [8] and [9]. Briefly, 100g of the vegetable sample was subjected to 105±3˚C in the oven for 5 hours and the moisture content determined gravimetrically. The ash content was gravimetrically determined by incinerating the sample in a muffle furnace at 550 ± 15 ℃ for 24 hours. Fats and fatty acids were determined by exhaustive extraction of sample with diethyl ether, by hydrolytic method. Pyrogallic acid was added to minimise oxidative degradation of fatty acids during analysis. The fats were extracted into ether and dried and the fatty acids methylated to fatty acid methyl esters (FAMEs) using sulphuric acid in methanol. FAMEs were then quantitatively measured by capillary gas chromatography with flame ionization detection. Total dietary fibre (TDF) was determined gravimetrically from the weight of protein and ash.

2.3. Determination of Crude Protein, Carbohydrates and Energy Values

Crude protein was determined using nitrogen analyser (LECO TruSpec, Gauteng) based on the Dumas or protein combustion method [10]. Elemental nitrogen released from protein combustion at 1200 ˚C was calculated by using the nitrogen to protein conversion factor of 6.25 times N, where N = total nitrogen [10]. Each determination was repeated twice and mean and standard deviations recorded. Available carbohydrates were determined by subtracting the total sum percent crude protein, total fat, TDF, moisture and ash from 100% dry weight of the leaves. The caloric value in (kJ) was estimated by multiplying the percentages of protein, total fat and carbohydrate by the factors 16.7, 37.7 and 16.7 respectively [11].

2.4. Determination of Minerals

Mineral composition was determined by atomic absorption spectrometry (AAS) after acid digestion of the samples [12]. Approximately 3g of the sample in a crucible was subjected to 550 ˚C for 4 hours, cooled and 2.5mL 6N HNO3 was added. The solution was filtered and diluted up to 100 mL with distilled water [12]. The solution was analysed for Ca, Mg, Na, K, P, Fe, Cu, Zn and Se by using Atomic Absorption Spectrophotometer and flame absorption spectrometry. Other elements included arsenic, tin, chromium and antimony. The results were obtained while using a working standard of 1000 ppm for each of the species.

2.5. Vitamin Analysis

2.5.1. Determination of Vitamin C

Ascorbic acid of the sample was estimated by using titrimetric method [13]. Briefly, 5 g of sample was weighed and macerated in 15 mL metaphosphoric and glacial acetic acid mixture in a beaker. One gram of activated charcoal was added to sample and left in boiling tubes for 10 minutes. The contents were thereafter filtered through Whatman No.1 filter paper into a conical flask. Exactly 10 mL metaphosphoric, and glacial acetic acid mixture were used to complete the extraction of the sample. Distilled water was added to the conical flask to make the solution up to 100 mL. A blank solution was titrated against 2-6 dichlorophenol indolephenol (DICHIP) dye in a beaker until pink colour was obtained. The quantity of dye used at a point of permanently pink colour was recorded. The quantity of ascorbic acid was calculated as: mg ascorbic acid / g sample = V x S x D, where V = volume of dye used to titrate, S = standardization value in mg ascorbic acid, and D = dilution factor.

2.5.2. Determination of Pro Vitamin A (β-carotene)

This was spectophotometrically achieved according to standard procedures [13]. Sample pigment was extracted with a 1:1 v/v acetone-n-hexane solution, followed by saponification and isolation of unsaponified extract using methanolic potassium hydroxide. The saponified extract was dried over anhydrous sodium hydroxide, evaporated to dryness and then made up to 10 mL with acetone-n-hexane. The mixture was chromatographed in a column of manganese oxide-hydro super-gel using 3.5% acetone-n- hexane. This separates carotene from other pigments that were not removed by saponification. The carotene extract was concentrated to dryness, dissolved in 100 mL acetone-n-hexane; this gave the test solution. The spectrophotometer was set at 436 nm and zero absorbance. The acetone-n-hexane was used to standardize the spectrophotometer. The test extract was poured into a 1cm cuvette and absorbance level read (T). The concentration of β-carotene was calculated as follows:

β-carotene (mg/100g) = -log Tx V x 100/ ($E^{\%}_{1cm}$xW), where T=absorbance, V=volume of eluate - 100, L =depth of cuvette=1cm, W=original weight of sample, $E^{\%}_{1cm}$=43.336nm [13].

3. Results

3.1. Proximate Composition

Proximate analyses revealed that the mature plants had relatively higher amounts of carbohydrates and protein than young shoots (Table I). However, the differences were not statistically significant (P>0.05). Sucrose, fructose and glucose were detected in both young shoots and mature plants while maltose was only detected in the mature plants. Lactose was not detected in any of the samples tested.

Table I: Proximate composition of Chenopodium album L. young shoots and mature plants (g/100g) dry weight

Nutrient	Young shoots	Mature plants
Carbohydrates	4.0 ± 0.0	7.0 ± 0.0
Dietary Fibre	37.0 ± 0.0	36.5 ± 0.0
Energy	700 ± 0.0[h]	800 ±0.0[h]
Moisture	7.4 ± 0.1	7.2 ± 0.2
Ash	17.6 ± 0.1	16.7 ± 0.1
Protein	32.2 ± 0.2	29.2 ± 0.3
Total sugar	4.6 ± 0.4	11.0 ± 0.8
Sucrose	1.1 ± 0.2	2.1 ± 0.1
Fructose	< 0.1	1.2 ± 0.2
Glucose	3.6 ± 0.3	7.3 ± 0.6
Lactose	0	0
Maltose	0	0.5 ± 0.0

Data are mean ± SD of triplicate determinations for each nutrient. h, KJ/100g

3.2. Vitamin and Fatty Acid Composition

The mature plants had higher amounts of β-carotene, 68±1.4 (µg/100g) compared to young shoots, 46±2.6 (µg/100g). However, the amount of vitamin C in young shoots was 5.6±0.2 (mg/100g) as opposed to 5.2±0.2 (mg/100g) in the mature plants. Saturated fats, mono-saturated fats and poly-saturated fats measured 0.1 ± 0.0, 0.6 ± 0.1 and 1.7 ± 0.1 (g/100g) in the young shoots as opposed to 0.2 ± 0.1, 0.7 ± 0.1 and 2.2 ± 0.1(g/100g) in the mature plants respectively. No transfats were detected in any of the samples.

3.3. Mineral Composition

Both young shoots and mature plants were rich in major macro/micro elements (Table II). However, the mature plants had significantly more calcium, magnesium and sodium ($P<0.05$). The young shoots were significantly richer in copper and iron ($P<0.05$).

Table II: Mineral composition of C. album L. young shoots and mature plants (mg/1000g) dry weight

Element	Young shoots	Mature plants
Calcium	12991±717	18213.2±598
Potassium	45799.3±12	49028.6±593
Magnesium	7982±175	13821.5±493
Sodium	48.8±0.4[b]	68.0±3.6[b]
Microelements		
Arsenic	1.8±0.1	1.8±0.1
Antimony	<0.05	<0.05
Copper	14.0±1.0	9.1±0.6
Chromium	0.90±0.0*	0.90±0.0*
Iron	218.1±2.6	120.4±4.1
Selenium	5.4±0.0	5.4±0.0
Tin	<0.05	<0.05
Zinc	26.2±1.2	23.0±1.9

Data are mean ± SD of triplicate determination for each element. b, mg/100g; *, mg/L

4. Discussion

The results of this study indicate that young shoots and mature plants of *C. album* may constitute alternative additional sources of important dietary components. It is worth mentioning that in the Eastern Cape Province and other parts of the country, the mature plants are usually not consumed probably because they are hard and difficult to chew even after cooking and also the myth that they can cause mental instability when consumed (unpublished findings). While their carbohydrate and protein may constitute a good source of energy and building block components respectively, their high fibre content is also important in increasing food bulk, regulation of intestinal transit and consistency of faeces [14].

Very small amounts of fat was detected in the young shoots and mature plants of *C. album*, a finding which is consistent with the results of other studies on indigenous leafy vegetables [15] and [16]. The detection of sucrose, glucose and fructose corroborates the findings of Ejoh *et al*. [17] who reported these to be the main sugars in most vegetables.

The mineral composition of *C. album* revealed high amounts of macro/micro elements (Table II). The detection of iron is of particular importance considering that 28% of 1-9-year old children in South Africa suffer from iron deficiency anaemia [5]. The inclusion of *C. album* as a vegetable in the diets of South African children and women of child bearing age would go a long way in alleviating the problem of iron deficiency anaemia. Equally important is the detection of zinc, an element which is crucial in normal functioning of the immune and gastrointestinal system [18]. Vitamins C and β-carotene were detected from the young shoots and mature plants of *C. album*, indicating that these vegetables if included in the diet could constitute an important source of these vitamins. However, unlike minerals, vitamins are much more susceptible to destruction by cooking and processing methods and care must be taken to maintain their availability after processing. The detection of arsenic and chromium in *C. album* is a cause for concern considering that these elements have been reported to be potential carcinogens especially when large amounts of vegetables are consumed with cumulative adverse effects on the nervous system of infants [19].

5. Conclusion

Young shoots and mature plants of *C. album* may play a crucial role in alleviating problems associated with nutritional deficiencies in South Africa. They have a major advantage of adaptability to harsh climatic conditions and therefore could fill a valuable niche in the production of food in rural areas where climate is not conducive for the propagation of exotic species which usually require steady supply of water for successful cultivation. Important dietary components of carbohydrates, protein, fibre, minerals vitamin C and β-carotene are herein detected from the young shoots and mature plants of *C. album*, thus providing preliminary scientific validation for their use as vegetable in the rural areas of South Africa. Further studies to determine the safety parameters of *C. album* as a vegetable and the effects of different processing methods on the bioavailability of its nutrients are imperative. These aspects are under consideration in our research group.

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7. References

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