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Original Research Article

Nutrient content of eight African leafy vegetables and their potential contribution to dietary reference intakes

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ABSTRACT

Nutrient content and potential contribution of one average portion towards nutritional requirements (recommended dietary allowance; RDA) of eight African leafy vegetables (ALVs) was determined. Compared to dark-green leafy vegetables (DGLVs) as sub-group, calcium and magnesium content were similar or considerably higher, vitamin C content was considerably lower, while pigweed had higher potassium content and spider flower similar folate content. All ALVs, except Chinese cabbage, had higher iron content. Black nightshade, pigweed, cowpea and spider flower leaves had higher β-carotene content than DGLVs. For children, pigweed and cowpea leaves emerged as good sources of vitamin A (>75% RDA), followed by spider flower, black nightshade, tsamma melon, Jew's mallow and pumpkin leaves (50–75% RDA). For iron, pumpkin leaves provided 50–75% RDA. Black nightshade, tsamma melon, pigweed and cowpea leaves contributed 25–50% RDA, with Jew's mallow, spider flower and Chinese cabbage providing <25% RDA. The ALVs were not a good source of zinc. Most ALVs were nutritionally similar to DGLVs. For most nutrients Chinese cabbage had considerably lower values than the other ALVs. Most of the ALVs can considerably contribute to requirements of vitamin A and, to a lesser extent, iron, both critical nutrients for developing countries.

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1. Introduction

Worldwide, a low intake of vegetables and fruit is among the top ten risk factors contributing to mortality (Ezzati et al., 2002). In developing countries, the diets of the poor are predominantly cereal-based and nutrient-poor, with few foods of animal origin, vegetables and fruit (Hotz and Gibson, 2007). In South Africa in 2000, an estimated 11.1 million males and 12.5 million females over 15 years of age had a low intake of vegetables and fruit (Schneider et al., 2007). The World Health Organization (WHO) recommends a daily intake of more than 400 g of fruits and vegetables per person to protect against diet-related non-communicable diseases (Lock et al., 2005; WHO, 2003), roughly double the amount consumed by the average South African (Rose et al., 2002). Vitamin A-rich vegetables and fruit, together with eggs and legumes, are the least consumed foods by South African adults (Labadarios et al., 2011). The South African diet typically lacks variety (Labadarios et al., 2011) and micronutrient deficiencies (vitamin A, iron and zinc) are widespread (Labadarios, 2007).

To address this situation, increased consumption of vegetables and fruit is promoted. However, affordability, availability and seasonality affect intake (Faber et al., 2013; Love et al., 2001). Under-utilised natural resources such as African leafy vegetables may contribute to improving food and nutrition security (Toledo and Burlingame, 2006). Reportedly, African leafy vegetables may grow on soils of low fertility; are relatively drought tolerant; provide good ground cover; and can be harvested within a short period of time (Shiundu, 2002).

Green leafy vegetables (locally called *morogo* and *imifino*) are frequently consumed in some rural areas of South Africa by children and adults (Faber et al., 2010; Labadarios et al., 2000; Nesamvuni et al., 2001; Steyn et al., 2001a,b). The leaves are

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typically harvested from the wild, but also from cultivated crops. In the present work African leafy vegetables refer to the collective of traditional leafy vegetables that form part of the culinary repertoire of contemporary African communities, whilst leafy vegetable refers to plant species of which the leafy parts, which may include young succulent stems, flowers and young fruit, are used as a vegetable (Jansen van Rensburg et al., 2007). A recent review on the nutrient content of African leafy vegetables consumed in Sub-Saharan Africa reported large variation in nutrient content and concluded that available information is limited and often incomplete (Uusiku et al., 2010). Most data focus on wild growing leaves, yet there is an increasing interest in the potential of cultivating African leafy vegetables.

Thus, the primary aim of this study was to determine the nutrient content of eight cultivated African leafy vegetables. The eight species were non-heading Chinese cabbage (*Brassica rapa* L. subsp. *chinensis*), black nightshade (*Solanum retroflexum* Dun.), pigweed (*Amaranthus cruentus* L.), Jew's mallow (*Corchorus olitorius* L.), spider flower (*Cleome gynandra* L.), cowpea (*Vigna unguiculata* L. Walp.), pumpkin (*Cucurbita maxima* Duchesne) and tsamma melon (*Citrullus lanatus* (Thunb.)). Secondary objectives were to explore the nutritional potential of these leaves by comparing their composition to dark-green leafy vegetables as a sub-group, and by estimating their potential contribution to dietary requirements.

2. Materials and methods

2.1. Production and collection of the plants for analysis

Two of the eight African leafy vegetables (black nightshade and Chinese cabbage) are grown commercially and for this study were cultivated at an irrigation scheme in the Limpopo Province. The other six African leafy vegetables are usually grown without addition of much fertiliser and were cultivated at the research institute in the Gauteng Province in South Africa.

Black nightshade and Chinese cabbage were planted from seed during the winter of July 2007 and June 2008, respectively, on a deep, red, well-drained soil at Dzindi Irrigation Scheme, Itsani, Thulamela Municipality, Vhembe District, Limpopo Province on plots that were 1000 m^2 in size. The method used to grow Chinese cabbage was explained in detail elsewhere and involved band-placed application of 40 kg N ha^{-1}, 60 kg P ha^{-1} and 80 kg K ha^{-1} at planting using the fertiliser mixture 2:3:4 (32), followed by two band-placed applications of 50 kg N ha^{-1} in the form of limestone ammonium nitrate (28%N) four weeks and six weeks after planting, respectively (Van Averbeke and Netshithuthuni, 2010). The irrigation strip from which the sample was taken had a homogeneous soil (based on the soil survey done). Sampling of the plants for analysis occurred when the first plants in the stand showed peduncle elongation, at which stage all plants in the stand had passed the tenth leaf stage. Only plants that had not reached the stage of peduncle elongation were sampled. The rate of application of fertilisers used for black nightshade at planting was the same as for Chinese cabbage. Sampling of the black nightshade plants occurred as soon as the first flowers appeared. Harvesting of black nightshade usually involves three shoot cuts (Van Averbeke et al., 2007) but only the first cut was used when sampling plants for analysis.

Pigweed, Jew's mallow, cowpea and tsamma melon were grown during the summer of 2007/2008 and pumpkin and spider flower during the summer of 2009/2010 at the Agricultural Research Council – Vegetable and Plant Institute, Roodeplaat in the Gauteng Province. In both years, seeds of the African leafy vegetables were sown directly in the same field, which was irrigated three times per week (about 15 mm per irrigation). In 2007/2008 the crops relied on residual fertiliser for nutrient acquisition. In 2009/10, compost was incorporated into the soil before sowing.

All eight of the African leafy vegetables were harvested between two to three months after sowing early in the morning, before 10:00 am. For each African leafy vegetable, three separate lots were harvested at random on the same day from different positions across the same field, so as to obtain representative sample batches for each species. Each lot of Chinese cabbage consisted of 10 whole mature plants that were cut at the base just above soil level keeping the leafy head intact. Individual lots of black nightshade and Jew's mallow comprised 40 plants each; those of pigweed and cowpea consisted of 50 plants each; individual lots of spider flower weighed approximately 3500 g each comprising plant stems with healthy edible leaves; pumpkin leaves (lamina with petiole) were cut from vines and each lot weighed approximately 1550 g; individual lots of tsamma melon leaves weighed approximately 1300 g.

Pumpkin and tsamma melon leaves were transported in labelled brown paper bags to the sensory analysis laboratory of the Meat Industry Centre of the ARC – LBD:API and processed the same day. All the other plants were sprinkled with water and each lot of plants loosely packed in a marked black plastic bag that was pierced to avoid "sweating" of the leaves and to allow some airflow. The bags were transported on the same day to the laboratory where they were kept in a cold storage room at +4 °C overnight for processing the next day. The individual lots for pigweed, Jew's Mallow and cowpea were transferred to buckets half-filled with water for overnight cold storage.

2.2. Sampling and processing of leaves for analysis

Each of the three collected lots per species was processed separately. For each lot of plants healthy edible leaves were removed from the base/stem and combined to constitute a composite sample. The number of leaves taken per plant varied between five and 15 for the different African leafy vegetables. In all cases only the lamina (leaf blade) that was removed from the petiole was taken for analysis except for Jew's mallow, pumpkin and spider flower leaves for which the lamina attached to the petiole was taken. The weights of the individual composite samples for each African leafy vegetable were as follows: Chinese cabbage, 980 g; pigweed, 550 g; spider flower, 870 g; pumpkin, 850 g; tsamma melon, 450 g; black nightshade, Jew's mallow and cowpea, 460 g.

The leaves were soaked and thoroughly washed with tap water (three to four times) to remove soil debris, followed by washing with distilled water. The leaves were air-dried on absorbent paper at room temperature for two hours. The leaves were cut into smaller pieces and homogenised using a household food processor; from this, a portion of adequate amount that was needed for all the nutrient analyses was further homogenised to a finer texture using a hand-held stick blender. Portions were transferred to marked plastic containers with screw caps. The containers were frozen at −20 °C until required for analysis. The portions for β-carotene analysis were dispatched to the Medical Research Council's (MRC) Laboratory in Cape Town. All nutrient analyses for each lot per species were therefore done on portions obtained from the same homogenised sample.

2.3. Chemical analyses of selected nutrients

Key nutrients, important in the diet of the nutritionally vulnerable, were determined for the various African leafy vegetables. The analyses were done on a double blind basis in a South African National Accreditation System (SANAS) accredited laboratory (with the exception of β-carotene). Reference samples

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