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Critical Review

Nutritional value of leafy vegetables of sub-Saharan Africa and their potential contribution to human health: A review

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ABSTRACT

This paper reviews the literature on African leafy vegetables (ALVs) consumed in sub-Saharan Africa. The aim is to evaluate the nutritional value of these plant species and their potential impact on the nutritional status of the people living in sub-Saharan Africa. Processing and the presence of antinutritional factors are taken into consideration as they adversely affect the nutritional content of the ALVs. The role of dietary fiber and other important components found in ALVs is also discussed due to their importance in the prevention of chronic and lifestyle diseases. Many of the ALVs are good sources of micronutrients, especially *Manihot esculenta* which contains 1970 μg retinol equivalents/100 g edible portion and 311 mg/100 g of vitamin C, as well as *Chenopodium album* with up to 6 mg/100 g iron, 18.5 mg/100 g zinc, 226 mg/100 g calcium and up to 211 mg/100 g magnesium. These vegetables may help to meet daily requirements of these and other essential nutrients, especially in individuals with marginal nutritional status. Furthermore, ALVs such as *Arachis hypogea* and *Bidens pilosa* are good sources of dietary fibre, while *Nasturtium aquatica*, *Urtic dioica* and *Xanthosoma mafaffa* are excellent free radical scavengers. In many instances ALVs have levels of these components that are higher than those of exotic vegetables such as spinach and cabbage. Factors such as storage, cooking methods and drying influence the micronutrient, antioxidant and antinutritional factor content of these vegetables. The consumption, cultivation and possibly the commercialization of these ALVs should therefore be promoted.

1. Introduction

Rural people of sub-Saharan Africa include indigenous and traditional vegetables in their diet. African leafy vegetables (ALVs), also known generically as African spinach, contribute significantly to household food security and add variety to cereal-based staple diets (Van den Heever, 1997). Traditionally, these vegetables are cooked and eaten as a relish together with a starchy staple food, usually in the form of porridge (Vainio-Mattila, 2000). Leafy vegetable (LV) dishes may be prepared from a single plant species or from a combination of different species, and the combinations eaten vary daily (Marshall, 2001). When the ALVs are cooked, salt is usually added to enhance the taste. Oil, butter, groundnuts, coconut, milk, bicarbonate of soda, tomato and onion are also added depending on availability and preference (Nguni and Mwila, 2007; Ogoye-Ndegwa and Aagaard-Hansen, 2003).

The consumption pattern of ALVs is different among households within different countries. In South Africa, the consumption pattern is highly variable and depends on factors such as poverty status, degree of urbanization, distance to fresh produce markets and season of the year (Jansen Van Rensberg et al., 2007). Poor households use these leafy vegetables (LVs) more than their wealthier counterparts (Jansen Van Rensberg et al., 2007). In a survey done in Nairobi (Kenya), ethnicity was shown to strongly influence households' choice and consumption of LVs (Kimiywe et al., 2007). In Bulamogi County of Uganda, the consumption of wild food plants is limited to casual encounters, periods of food shortages and as supplements to major food crops (Tabuti et al., 2004).

The frequency of consumption of ALVs has decreased over the years, probably because ALVs are often considered to be inferior in their taste and nutritional value compared to exotic vegetables

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such as spinach (*Spinacea oleracea*) and cabbage (*Brassica olearacea*) (Weinberger and Msuya, 2004). In addition, preference of ALV species differs depending on the gender and age of consumers, as well as cultural background and geographical location (Jansen Van Rensberg et al., 2004). When available, the ALVs are preferred over exotic vegetables (Marshall, 2001; Shackleton et al., 1998). Several studies have indicated that the ALVs contain micronutrient levels as high as or even higher than those found in most exotic LVs (Kruger et al., 1998; Odhav et al., 2007; Steyn et al., 2001; Weinberger and Msuya, 2004). LVs are cooked using traditional methods, and the excess is often dried and stored for consumption during the off-season (Vainio-Mattila, 2000). The cooking or preparation methods and period of cooking may affect the nutritional value as well as the bioavailability of many nutrients (Gupta and Bains, 2006; Lešková et al., 2006).

This paper reviews studies on LVs in sub-Saharan Africa. The purpose of this paper is to determine whether these ALVs can potentially contribute to the alleviation of protein-energy malnutrition and micronutrient deficiencies while taking into account the effect of antinutrients. Furthermore, the role of antioxidants found in these ALVs in the prevention of diseases will be discussed. An additional purpose of this review is to encourage further research into the nutritional as well as antioxidant content and activity of ALVs in order to promote the consumption, cultivation and commercialization of these vegetables.

2. Undernutrition in sub-Saharan Africa

The sub-Saharan African region covers an area of 24.3 million square kilometers and consists of 48 countries, with an estimated population of around 788 million, just over 10% of the world's population (UNAIDS, 2007).

Sub-Saharan Africa has the highest prevalence of undernutrition in the world, with one in three people being chronically hungry (FAO, 2008), the majority of whom live in the rural areas. Poverty in the region is associated with unemployment, worsening of the HIV/AIDS pandemic, as well as natural- and human-induced disasters (FAO, 2006; FAO/WFP, 2007). Three-quarters of the nearly 11 million children in developing countries that die before their fifth birthday are in sub-Saharan Africa and South Asia (FAO, 2005). Nutrient deficiencies of vitamin A, iron and zinc are widespread (FAO, 2001). Worldwide, an estimated 33.3%, or 190 million children younger than 5 years are at risk of vitamin A deficiency, with Africa and South-East Asia having the highest prevalence of vitamin A deficiency, 44.4% and 49.9%, respectively (WHO, 2009). In 1999, the National Food Consumption Survey conducted in South Africa found that a significant majority of children aged 1–9 years consumed a diet deficient in energy and of poor nutrient density (MacIntyre and Labadarios, 2000). The deficiency of one micronutrient can exacerbate the deficiency of another, thus there is likely to be concomitant deficiencies of more than one micronutrient in individuals (Black, 2003; Scrimshaw and Sangiovanni, 1997).

A large proportion of households in sub-Saharan Africa is poor and exists on a diet composed primarily of staple foods prepared from cereals (maize, millet, sorghum, teff), tubers (cassava, cocoyam, yam) and plantains (Oniang'o et al., 2003), which are generally low in micronutrients. These households rely mostly on the consumption of LVs to fulfill their daily requirements of bioavailable micronutrients. A study done on the consumption of fruits and vegetables in 10 sub-Saharan African countries by Ruel et al. (2005) found that none of the countries reached the WHO/FAO recommended minimum daily intake. The study further found that, with the exception of Kenya, the mean consumption in most countries did not even reach half of the recommended intake. A low intake of vegetables and fruit does not only put people at risk for micronutrient deficiencies, but it is also among the top 10 risk factors contributing to mortality worldwide (Ezzati et al., 2002). Smith and Eyzaguirre (2007) argued that in sub-Saharan African countries ALVs could play an important role in the WHO global initiative on increased consumption of vegetables and fruit.

3. ALVs and their potential contribution to health

Vegetables are a rich source of vitamins and other components that contribute to antioxidant activity in the diet (Gupta and Bains, 2006), while no single vegetable provides all the nutrient requirements. A diversified diet is needed to meet daily micronutrient requirements (Grusak and Dellapenna, 1999). The role of ALVs in the diet is often difficult to capture using conventional dietary assessment methodologies (Grivetti and Ogle, 2000). Available data for the micronutrient content and antioxidant activity of some ALVs are for raw samples. Processing such as cooking and drying can affect the nutritional content and antioxidant activity (Agte et al., 2000) and therefore further studies determining these effects are essential.

In this review of the literature, research pertaining to a total of 193 plant species belonging to 108 families found in 12 sub-Saharan African countries have been studied with regards to aspects such as their ethnobotany, trade, dietary and medicinal use, as well as their nutritional value, antioxidant activity and antinutritional factors. Nutritional data are available for 31 plant species (Tables 1, 2 and 4). It is, however, difficult to compare data from different studies due to differences in the methods used for quantification, units of measurement, source, time of collection, seasonal conditions and geographical regions. From the literature search, various analytical procedures have been used for the determinations of proximate compositions, and micronutrients, as well as other important components of ALVs. Proximate compositions have been determined using AOAC methods (crude protein content using the Kjedahl method with a nitrogen to protein conversion factor of 6.25, fibre content determined as either dietary fibre (non-starch polysacharrides and lignin) or crude fibre (cellulose, lignin and hemicellulose), carbohydrate determined either by difference or by enzyme extraction method for total available carbohydrates, fat using the soxhlet method (Table 1), vitamins by HPLC with fluorometry procedures (Table 3) and minerals by using atomic absorption spectrophotometry (Table 4).

4. Protein content of ALVs and contribution to health

The protein content of ALVs range between 1 and 7 g/100 g edible portion (Table 1). Some ALVs have higher protein content than exotic LVs. FAO (1990) and Odhav et al. (2007) reported that the crude protein content of both *Senna occidentalis* and *M. esculenta*, was 7 g/100 g edible portion (fresh weight basis), which is greater than that reported for *Brassica oleracea* subsp. *capitata* (Mosha and Gaga, 1999) and *S. oleracea* (Kruger et al., 1998) with values of 1 g/100 g and 3 g/100 g. However, compared to legumes, ALVs are not very good sources of protein. Thermal processing enhances the digestibility of proteins (Gibson et al., 2006), but can also lead to protein degradation that lowers the protein content of LVs. Differences in the agro-climatic conditions may account for the variation in protein content for *Bidens pilosa* observed by FAO (1990), Kruger et al. (1998) and Odhav et al. (2007).

Protein-energy malnutrition (PEM) manifests as marasmus (mostly energy deficient), kwashiorkor (mostly protein deficient) or a combination of the two (marasmic-kwashiorkor) (Müller and Krawinkel, 2005). In sub-Saharan Africa, 28% of children under-5 years are moderately or severely underweight (underweight is an indicator for PEM) (UNICEF, 2006). The relatively low level of protein in ALVs necessitates supplementation with animal protein or proteins from legumes to have an impact on PEM.