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South African Journal of Botany 72 (2006) 492–497

SOUTH AFRICAN JOURNAL OF BOTANY

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Review

The suitability of wild vegetables for alleviating human dietary deficiencies

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Received 28 September 2005; accepted 22 February 2006

Abstract

Micronutrient deficiency is a universal problem, which presently affects over two billion people worldwide, resulting in poor health, low worker productivity, high rates of mortality and morbidity. Deficiency in micronutrients has led to increased rates of chronic diseases and permanent impairment of cognitive abilities in infants born to micronutrient deficient mothers. Wild vegetables have been the mainstay of human diets for centuries, providing millions of consumers with important micronutrients, such as vitamins and minerals needed to maintain health and promote immunity against infections. Compared to conventional cultivated species, wild vegetables are hardy, require less care, and are a rich source of micronutrients. Hence, they could make an important contribution to combating micronutrient malnutrition as well as providing food security. Unfortunately, wild vegetables are currently underutilized, and have been neglected by researchers and policy makers. Their promotion and integration into human diets could assist in their protracted use and consequent conservation. However, the chemical, nutritional and toxicological properties of especially local wild vegetables, the bioavailability of micronutrients present in these, and their modification by various processing techniques still need to be properly established and documented before their use as an alternative dietary source can be advocated. Such information would be of fundamental importance in addressing dietary deficiencies in impoverished African rural communities.

Keywords: Wild vegetables; Micronutrients; Bioavailability; Food processing

Contents

1. Introduction

Micronutrient deficiencies have become a serious global problem, especially in areas where the diet lacks variety (Welch and Graham, 1999; Kennedy et al., 2003). There are approximately 40 vitamins and minerals, which are considered essential for physical and mental development, immune system and metabolic processes. In particular, iron, iodine and vitamin A have been attributed to the most widespread forms of micronutrient afflictions, while the prevalence of zinc and folate (natural form of folic acid) deficiencies are thought to be significant, though the extent of their prevalence has not yet been established (Kennedy et al., 2003). In 2000, the World Health Organization (WHO)

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doi:10.1016/j.sajb.2006.02.003

estimated that more than 3.7 million deaths could be attributed to underweight in children; in addition to these, deficiencies in iron, zinc or vitamin A caused an additional 750 000 to 850 000 deaths (Food and Agriculture Organisation, 2004).

Three main strategies that have been applied to address micronutrient malnutrition include supplementation, fortification and dietary modification (Kennedy et al., 2003). Supplementation is a technical approach where nutrients are delivered directly by means of syrup or pills, while fortification entails utilizing widely accessible and commonly consumed foods to deliver one or more micronutrients. Dietary modification (or food-based strategies) focuses on increasing the amount of micronutrients consumed in the diet and on making a larger share of these nutrients more readily available for absorption by the human body (Ruel, 2001). This paper focuses on dietary modification.

It has been observed that diets in many developing countries are not optimal (Johns, 2003) and that globalization and modernization in agriculture has resulted in simplification of diets and reliance on a few staple crops (Welch and Graham, 1999). Hence, a number of authors have advocated the use of food-based strategies to achieve optimal dietary requirements to combat micronutrient deficiencies (Ali and Tsou, 1997; Underwood, 1999; Ogle, 2001; Tontisirin et al., 2002; Johns, 2003; Johns and Sthapit, 2004). Integrating wild vegetables into diets has been promoted as the most practical and sustainable way to achieve this (Chadha and Oluoch, 2003), since such vegetables are efficient sources of several important micronutrients, both with respect to unit cost of production and per unit area of land (Ali and Tsou, 1997). Indeed, there is increasing consensus that wild foods could significantly contribute to alleviating hunger and malnutrition (Burlingame, 2000). In view of this, neglected crops, non-commercial foods, and wild foods are receiving renewed attention, with the recognition that they could become useful parents in breeding programs, convenient sources of income, and vehicles for improved nutrition and increased food supply (Burlingame, 2000; Grivetti and Ogle, 2000; Padulosi et al., 2002; Olorode, 2004). Also, there is increasing evidence to suggest that nutritional success is linked to diversification of the food base (Altieri et al., 1987), which could be achieved by modifying agricultural practices and increasing collection of wild plant germplasm (Grivetti, 1979). The fact that traditional rural communities are nutritionally successful, even during periods of drought, affirms the importance of recognizing and utilizing traditional wild food resources (Altieri et al., 1987). In view of all these findings, this review examines evidence advocating the use of wild vegetables for combating micronutrient deficiencies in human diets.

1.1. Micronutrient content of wild vegetables

A large body of information exists on the micronutrient composition of wild vegetables, generally indicating higher mineral and vitamin contents than in cultivated vegetables. Guerrero et al. (1998) compiled a comprehensive nutrient report of wild vegetables consumed by the first European farmers, and nearly all the species indicated good amounts of several micronutrients. In particular, *Verbena officinalis* was found to be an excellent source of calcium and magnesium, which were present at concentrations of 3 mg/g Ca and 1.6 mg/g Mg of fresh leaf mass respectively. In another study, in which 25 wild vegetables were analyzed 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. Also, in a similar study conducted in two Vietnamese districts, Ogle (2001) found that all but one of the 28 analyzed species had higher carotene concentrations than the locally cultivated species, with 14 of the wild species possessing higher calcium concentrations and 12 of the wild species possessing higher iron contents than the cultivated vegetables. The relatively high beta-carotene contents observed in 11 out of the 28 wild species ranged from 2.5 μg/g in *Commelina communis* to as high as 50 μg/g in *Basella rubra*, *Limnocharis flava* and *Sauropus androgynus*.

Other studies conducted by Booth et al. (1992) and Freyre et al. (2000) in South America and 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. Studies conducted on wild African vegetables by Freiberger et al. (1998) in Niger, Vainio-Mattila (2000) in Tanzania, and Nesamvuni et al. (2001) in South Africa also underscored their significant contribution as sources of micronutrients. However, the nutritional quality of four wild vegetables analyzed in Ghana were found to be in the same range as conventional vegetables (Wallace et al., 1998), these findings implying the requirement for further studies, covering a wide range of species before wild vegetables can be recommended as substitutes for conventional ones.

Vitamin-specific studies have also concluded that wild vegetables are good sources of folate with concentrations ranging between 0.10 and 0.96 mg/g in blanched vegetables. In one such study, Ogle et al. (2001) reported that wild vegetables contributed 21% of dietary folate in one Vietnamese district and 14% in another. In another study, it was reported that of the 70 wild vegetables eaten by the tribal people in south India, 36 had high vitamin A concentrations with only four having low contents (Rajyalakshmi et al., 2001).

1.2. Multiple roles of wild vegetables

The multiple roles of wild traditional vegetables as both food and medicinal sources have been widely documented. These include: the listing of 28 medicinally important leafy vegetables by Ayodele (2005), the reported medicinal uses of 24 indigenous leafy vegetables in south western Nigeria by Adebooye and Opabode (2004), the documented antibacterial activities of various vegetables and fruits consumed in the United States of America (Lee et al., 2003), and the cataloguing of wild vegetables with both therapeutic and dietary functions in Vietnam (Ogle et al., 2003). Furthermore, wild vegetables have been reported to contain comparatively high amounts of Vitamins A and C. These, and other antioxidant micronutrients present in fresh fruits and vegetables (Szeto et al., 2002), promote good health by assisting in preventing cancer and high blood pressure, stimulating the immune system, improving drug metabolism, and tissue regeneration (Rayner, 1998; Krebs-Smith and Kantor, 2001; Walingo, 2005).

1.3. Variation in micronutrient content and bioavailability

Inter-specific variations in micronutrient contents have been well documented. Yildirim et al. (2001), for example, illustrated considerable inter-specific variation in potassium contents in eight wild vegetables utilized in Turkey, the lowest potassium content of 5.42 mg/g K found in *Polygonum bistorta*, with intermediate concentrations of 10.2 mg/g K and 11.4 mg/g K observed in *Camelina rumelica* and *Astrodaucus orientalis* respectively, and highest concentration of 15.4 mg/g K found in *Lathyrus tuberosus.* However, less attention has been directed to examining to what extent micronutrient contents of wild vegetable species vary according to geographical location, agricultural practice, and climate. Also, comparisons of micronutrient concentrations between wild and cultivated cultivars of similar vegetable species are lacking.

Apart from these deficits, little is also known of the actual bioavailability of micronutrients in wild vegetables, which is important from a consumptive perspective. Gregory (2001) indicated many areas of uncertainty in the understanding of folate bioavailability. However, his perspective was challenged by other authors who argued that increased vegetable consumption could improve micronutrient status, particularly with respect to iron and vitamin A (de Pee et al., 1996), and called for urgent evaluation of dietary approaches for combating the key micronutrient deficiencies. One potential solution is the selection of genotypes possessing good bioavailable sources of micronutrients, especially iron whose bioavailability in vegetables is known to be poor (Ruel and Levin, 2000). In one such study, 12 species of *Amaranthus* were screened for total and bioavailable iron in greenhouse and field experiments (Rangarajan and Kelly, 1998), the results indicating the potential for selecting species genotypes, for example, *A. tricolour,* with a high bioavailability of iron.

Wild vegetables, especially dark green leafy plants, are known to contain oxalates, phytates, nitrates, tannins and saponins known to reduce the absorption of certain micronutrients in the body (Guil et al., 1997; Wallace et al., 1998; Steyn et al., 2001; Gupta et al., 2005). Oxalic acid, for example, interferes with calcium absorption by forming insoluble salts of calcium, whereas phytates bind iron, zinc, calcium and magnesium rendering them unavailable (Gupta et al., 2005). Conversely, some compounds increase micronutrient bioavailability in diets. A typical example is the increased absorption of iron when combined with Vitamin C. Also, there is emerging evidence that nutritional deficiencies involve more complex interactions than originally anticipated. An example is the association of rickets with Vitamin D deficiency, which more recently has also been connected to calcium deficiency in diets (Kennedy et al., 2003). In another study performed in India, in which biological interactions between beta-carotene and other micronutrients, viz: lutein, lycopene, polyphenols and vitamin C, were examined in six varieties of green leafy vegetables, it was found that the interactions enhanced the stability of beta-carotene and its potential bioavailability (Steyn et al., 2001). Such studies highlight the complex nutrient on nutrient interactions in the human diet (Kennedy et al., 2003).

1.4. Micronutrient contents of processed foods

There exists a wide variation among different wild vegetables in the gross contents of micronutrients and antinutrients in the raw form. However, there is general lack of information on micronutrient contents of cooked wild vegetables (Agte et al., 2000), though it is generally accepted that micronutrient content is affected by food processing (Umoh and Bassir, 1977; Ajayi et al., 1980; McKillop et al., 2002), the magnitude of which is influenced by different cooking methods as well as food additives (Steyn et al., 2001; Gayathri et al., 2004).

When wild vegetables are not eaten in their fresh form, their micronutrient content may be preserved by blanching before consumption. Blanching is a process of heating vegetables to a temperature high enough to destroy enzymes present in leaf tissues, to prevent enzymatic-induced colour changes and shorten their drying and dehydration times (Oboh, 2005). This process is normally carried out in hot water or in steam to reduce or eliminate bitterness and acid components that are common in leafy vegetables. However, excessive blanching can also lead to undesirable loss of colour, flavour, texture and nutrient quality (Negi and Roy, 2000).

The potentials of traditionally cooked green leafy vegetables to supply bioavailable iron, beta-carotene, riboflavin, thiamine, folic acid, ascorbic acid, zinc and copper for vegetarian diets have been investigated by Agte et al. (2000). He found that the vegetables cooked in this manner were adequate supplements for iron, beta-carotene and vitamin C, but not riboflavin, folic acid, zinc and copper. Studies in southern Brazil have shown that the mineral profile of leafy vegetables was not affected by cooking for 3 min (Kawashima and Soares, 2003), with blanching and cooking for up to 15 min even resulting in significantly increased riboflavin bioavailability in cowpea, peanut and pumpkin leaves. Similarly, increased calcium and zinc bioavailability in *Chenopodium album* and *Trigonella foenum graecum* following blanching was reported in India (Yadav and Sehgal, 1999). Conversely, thermal processing was reported to significantly reduce riboflavin bioavailability in amaranth and sweet potato leaves (Mosha et al., 1995a,b), and in another study conducted in Nigeria it was reported that blanching significantly decreased free scavenging radical contents in seven out of eight green leafy vegetables (Oboh, 2005). Despite these contradictory findings, there is a general consensus that blanching is an effective means for reducing antagonistic nutritional factors in green vegetables (Mosha et al., 1995a,b). This is supported by the reported significant reductions in oxalic acid, and concomitant decreases in phytic acid and polyphenol contents, in *Amaranthus tricolour*, *Chenopodium album*, *Trigonella foenum grecum* and *Spinacia oleracia* following blanching (Yadav and Sehgal, 2003). Added to these beneficial effects, is the reported reduction in trypsin and chymotrypsin inhibitor activities in leafy vegetables following blanching

(Mosha and Gaga, 1999). However, still requiring investigation are a comparison of conventional and microwave blanching methods on the nutritional status of wild vegetables (Mosha et al., 1995a,b).

1.5. Effect of drying and storage on micronutrient content

Since wild vegetables are only seasonally available and highly perishable, suitable processing and storage techniques need to be applied to conserve their micronutrients (Negi and Roy, 2000; Negi and Roy, 2001). Seasonality can be partly overcome by blanching, which is usually the primary step in the processing of vegetables, before drying and storage (Mulokozi and Svanberg, 2003). Numerous studies have examined the effects of drying on retention of nutrients in leafy vegetables, but information on their changes during storage of dehydrated leaves is still lacking (Negi and Roy, 2001). In fact, reported effects of different drying and storage methods on the levels of micronutrients in wild vegetables are contradictory. For example, in Tanzania, the traditional processing practices of sun/shade drying and storing in ventilated containers resulted in significantly decreased ascorbic acid, riboflavin and thiamine contents in all the vegetables investigated (Mosha et al., 1995a, b). Similarly, Speek et al. (1988) reported substantial losses of beta-carotene during such processing, while no significant effects of drying and storage were observed on calcium and zinc contents in such vegetables (Yadav and Sehgal, 1999). Noteworthy, is that the drying process is an important factor in micronutrient retention, thus suggesting that processing of vegetables by hot water blanching followed by sun drying, or steam blanching followed by cabinet drying could provide an efficient means of conserving micronutrients (Negi and Roy, 2001).

1.6. Wild vegetable endorsement

A comparison of the consumption of vegetables and fruits in ten European countries with the World Health Organization's recommendations on minimum intake per person per day revealed that all countries except Greece had vegetable ingestion below the recommended minimum (Trichopoulou et al., 2001). Also, the percentages of low vegetable consumers exceeded those of other food groups (such as, fruits) indicating there was still a lot to be done in promoting the use of wild vegetables. Indeed, these have been the mainstay of African diets for centuries, providing millions of consumers with the vitamins, nutrients, and minerals needed to maintain health and fight off hazardous infections (Grivetti and Ogle, 2000). In a recent survey, it was estimated that of the more than 45 000 plant species in Sub-Saharan Africa, at least 1000 of them could be eaten as green leafy vegetables (Future Harvest, 2001). Added to this, the Plant Resources of Tropical Africa listed 6376 plants as being of value to man, 397 of which were wild vegetables (Adebooye and Opabode, 2004). This list is a probable underestimate, since local people exploit a much wider range of plants as a food source than reported in the literature (Blench, 1997; Padulosi et al., 2002).

2. Conclusions

Lack of proper knowledge on the nutritive value of wild vegetables, their preparation, and preservation has been cited as an important deterrent to their general acceptance and utilization (Mnzava, 1997). Even though wild vegetables form an integral part of traditional agricultural systems (Grivetti and Ogle, 2000; Adebooye and Opabode, 2004; Johns and Sthapit, 2004), current research still appears to be focused on the popular or commonly used species, some of which may have already been fully or partially domesticated. Therefore, it is vital that more research is conducted on potentially exploitable wild species, (Mnzava, 1997). This would promote their increased utilization thereby simultaneously contributing to conserving their genetic resources (Eyzaguirre, 1997; Padulosi et al., 2002). Such research could commence with the collection and databasing of traditional knowledge and information on the distribution and use of wild vegetables in rural communities (Padulosi et al., 2002). Such information would be of fundamental importance in addressing dietary deficiencies in impoverished African rural communities.

Acknowledgements

The authors are grateful to the National Research Foundation of South Africa for its financial support.

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Edited by C.F. Musil