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Short Communication

Glucosinolates in leaves of *Moringa* species grown and disseminated in Niger

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Moringa leaves rank first among the most widely consumed leafy vegetables in Niger. Glucosinolate contents in leaves of five accessions of three *Moringa* species (*M. oleifera*, *M. stenopetala* and *M. peregrina*) ranged from 2.65 µmol/g in old leaves of *M. stenopetala* (Ethiopian-1) to 28.62 µmol/g in young leaves of *M. oleifera* (ICG-42). An Indian introduction, PKM-1 (*M. oleifera*) gave maximum leaf yield (7.5 t/ha) and had maximum consumer preference than the local (*M. oleifera*) and Ethiopian-1 (*M. stenopetala*) genotypes. Large scale dissemination of PKM-1 and use of other species under different production systems are described.

Key words: Glucosinolate, *Moringa* spp., Niger

INTRODUCTION

Moringa (*Moringa* spp.) is a softwood perennial tree that belongs to the monogeneric family Moringaceae (order Capparales). Among the 13 species of the genus *Moringa* (Ray et al., 2006), *M. oleifera* (synonyms: horseradish tree, drumstick tree, benzolive tree, kelor, marango, mlonge, moonga, mulangay, nébéday, saijhan, sajna or ben oil tree) and *M. stenopetala* (Ethiopian moringa) are most commonly cultivated in South India, Ethiopia, Philippines, Sudan and other tropical countries (Fahey, 2005). *M. oleifera* is a native of the sub-Himalayan tract of the Indian subcontinent, whereas *M. stenopetala* and *M. peregrina* originated in Ethiopia and the Arabian Peninsula, respectively. In a survey of 120 Asian indigenous vegetables for nutrient content, antioxidant activity and traditional knowledge on their medicinal uses, *M. oleifera* was among the most promising species (Ray et al., 2006). This tree is an outstanding source of nutrients in developing regions of the world where undernourishment is a major concern (Fahey, 2005). In Niger, moringa is among the most preferred and consumed leafy vegetables. Being a multi-purpose perennial (Bennett et al., 2003), moringa has considerable potential to contribute to food security under predicted adverse effects of climate change on agriculture. Glucosinolates are a family of natural products present in species of the order Capparales (Bellostas et al., 2007a). These phytochemicals are precursors of a wide range of bioactive compounds with demonstrated antibiotic, anticancer and antioxidant properties (Fahey, 2005). Glucosinolate profile and concentration are species- and genotype-dependent; even different tissues of a single plant show variations (Bellostas et al., 2007b). Concentration also is influenced by growing conditions and the plant's growth stage (Bellostas et al., 2007b). The glucosinolate content of young and old leaves of moringa species grown in Niger were analyzed. The results are discussed in the light of our efforts to promote moringa under different production systems.

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MATERIALS AND METHODS

Five accessions of three *Moringa* species were used (Figure 1). Young and old leaves were collected from three trees (2 - 3 years old) of each species in September, one of the months when moringa leaves are typically consumed. Four of these lines are being maintained at the AVRDC/ICRISAT vegetable breeding project at ICRISAT farm at Sadore, Niger and a local line was grown near Niamey, Niger. Leaves were pooled and air-dried at

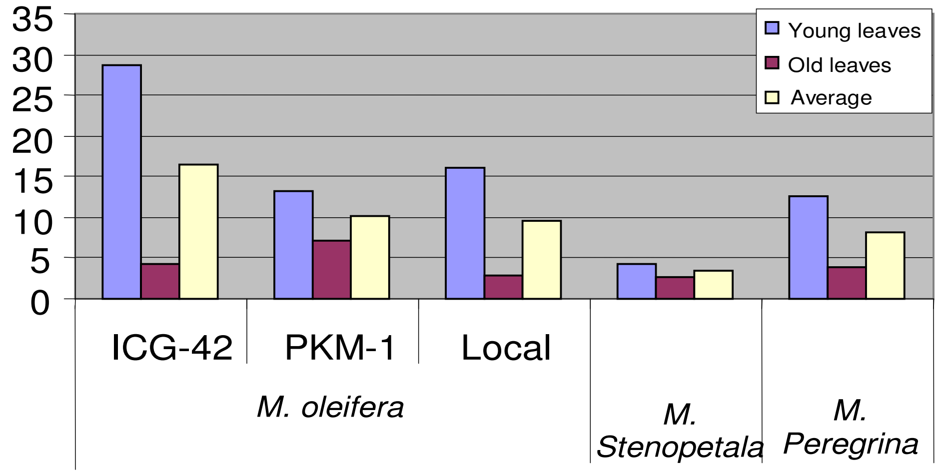

Figure 1. Glucosinolates (µmol/g) in leaves of moringa species.

room temperature (25ºC) prior to shipping to the laboratory in Copenhagen, Denmark. It should be freeze-dried and ground samples (0.8 g) were extracted in duplicate at 100ºC in a Pressurized Solvent Extraction (PSE) using 100% methanol as solvent and with a preheating step (Petersen et al., 2007). The extracts were then dried, re-dissolved in 5 mL milli Q water and glucosinolate concentration was estimated along with two internal standards. Desulphoglucosinolates were determined by Micellar Electrokinetic Capillary Chromatography.

RESULTS AND DISCUSSION

Glucosinolate content

The glucosinolate content in young and old leaves of five accessions varied from 2.65 µmol/g in old leaves of *M. stenopetala* (Ethiopian-1) to 28.62 µmol/g in young leaves of *M. oleifera* (ICG-42). All three *M. oleifera* accessions had higher glucosinolate concentration than the two other moringa species (Figure 1). Glucosinolate content is species and cultivar- specific (Bellostas et al., 2007b). Young leaves of all species consistently showed higher glucosinolate concentration than old leaves, in keeping with results shown for other glucosinolate-containing species (Bellostas et al., 2007b) as well as for moringa (Bennett et al., 2003). Despite showing similar patterns, the glucosinolate values obtained in this study are lower than those reported by Bennett et al. (2003). This difference can likely be attributed to the different genotypes used in the studies, differences in growth conditions, as the extraction procedure although new, has been proven accurate (Petersen et al., 2007). As previously described (Bennett et al., 2003), 4-(α-$_L$-rhamnopyranosyloxy)-benzylglucosinolate was found to be the quantitatively dominating glucosinolate present in all the species examined. In addition to 4-(α-$_L$-rhamnopyranosyloxy)-benzylglucosinolate, three different acetyl derivatives of the same glucosinolate were also found in the *Moringa* species examined. Glucosinolates are a complex group of compounds (Bellostas et al., 2007a) and depending on their actual structure and concentration in the diets, the biochemical – physiological effects can be either positive or negative (Andersson et al., 2008). Hence, there is a need for generating additional information on the potential impact on health of the moringa glucosinolates.

The average glucosinolates content in seeds of *M. oleifera* variety PKM-1 (43.14 µmol/g) was significantly higher than that in the young (13.16 µmol/g) and old leaves (7.12 µmol/g), as also shown earlier (Bennett et al., 2003). Reproductive organs tend to accumulate larger amounts of glucosinolates than vegetative tissues (Bellostas et al., 2007b). Hence, in a food-based approach to fight hidden hunger (Ray et al., 2006), moringa pod consumption should also be encouraged in country like Niger where moringa leaves are frequently consumed.

Antioxidants

Significant variation in antioxidant activity (AOA) has been reported in four *Moringa* species, with *M. peregrina* showing maximum AOA (Ray et al., 2006). In this study, leaves of all three species surveyed had a high content of similar flavonoid glycosides (data not given) and it is likely that these compounds represent an important part of the AOA in moringa leaves as also shown by Ray et al. (2006).

Promotional efforts

Among all genotypes, PKM-1 variety of *M. oleifera* gave maximum yield of about 7.5 t/ha of leaves under on-station irrigated trials. PKM-1 was developed in India

Table 1. Consumer preference of leaves of three moringa genotypes.

Consumer type (# of tasters)	Taste ranking		
	M. oleifera		*M. stenopetala*
	Local	PKM-1	Ethiopian-1
Nigerian-Rural (25)	3.12	4.72	1.80
Nigerian-Urban (19)	2.85	4.45	2.35
Non-Nigerian (8)*	2.38	4.62	2.50
Mean ± SE	2.78 ± 0.175	4.60 ± 0.098	2.22 ± 0.144

Note: Each participant tasted leaves (boiled in water and salt for one hour) of three genotypes (labeled A, B, C) and ranked them on a 1-to-5 scale; *First time tasted moringa leaves.

primarily for pods, but prior to its dissemination consumer preference for leaves of PKM-1, a local line of *M. oleifera* and *M. stenopetala* was studied. An organoleptic taste trial with cooked leaves revealed that PKM-1 leaves were most preferred by both urban and rural consumers in Niger (Table 1). This meant that moringa growers could realize better returns from cultivating PKM-1 for pods and leaves and opened the door for large scale dissemination of it in Niger. PKM-1 is being promoted under different irrigated cropping systems including African Market Garden (AMG), a low pressure drip irrigation system predominantly based on vegetable cultivation, promoted in the Sudano-Sahel region of West Africa (Pasternak et al., 2006).

Moringa is promoted in a range of developmental schemes operating in Niger. The most recent effort is through moringa values chain development, a project implemented by Co-operative League of USA (CLUSA), which involves on-station and on-farm trainings in moringa leaf and seed production for trainers and growers. In the past couple of years, approximately 135 hectares (based on on-station seeds produced and disseminated) of PKM-1 have been planted in Niger. Cultivation of Ethiopian moringa (*M. stenopetala*) along with xerophytic high value trees and indigenous vegetables such as okra (*Abelmoschus esculentus*) are being disseminated under rain-fed conservation agriculture systems on degraded lands, a system that we call Bio-Reclamation of Degraded Land (Pasternak et al., 2009). The desert moringa (*M. peregrina*) currently is being evaluated for its suitability as a root stock for PKM-1 to enable its cultivation under rain-fed/dryland agriculture. It would be worthwhile to appraise the impact and contribution of these dissemination efforts toward nutritional security and livelihood.

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