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Actual and Potential Applications of *Moringa stenopetala*, Underutilized Indigenous Vegetable of Southern Ethiopia: A Review

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Abstract

Moringa stenopetala, locally called Haleko, is an indigenous vegetable tree native to southern Ethiopia and grown mainly for its food value. It is a drought tolerant and fast growing tree that has high nutritional value and the potential to alleviate malnutrition in the tropics. Millions of people in southern Ethiopia consume its leaves as a staple vegetable. It also has potential medicinal and industrial applications and significant economic contributions. Despite its actual and potential roles, *M. stenopetala* has been given little research and development attention. This paper reports actual and potential uses of *Moringa stenopetala* and highlights research gaps that need to be addressed in the future.

Keywords: *Ethiopia; Haleko; medicinal value; Moringa stenopetala; nutritional value; potential applications*

1. Introduction

Moringa is a tropical plant belonging to the family *Moringaceae* that grows throughout the tropics. The genus *Moringa* consists of 13 species (NRC, 2006) of which only *Moringa oleifera* has been accorded research and development attention. *M. oleifera* is native to sub-Himalayan tracts of northern India and is commonly referred to as "horseradish tree" or "drumstick tree" (Jahn, 1991). Moringa is a multipurpose tree of significant economic importance, as it has vital nutriational, industrial, and medicinal applications (Jahn, 1991; NRC, 2006).

On the other hand, the rest of the species of Moringa have not been studied in detail, and their potential uses have not been fully understood. *Moringa stenopetala* was domesticated in the east African lowlands and is indigenous to southern Ethiopia. Many different ecotypes and varieties of *M. stenopetala* are found in Ethiopia. *M. stenopetala* is often called "cabbage tree" and is an important indigenous vegetable in south western Ethiopia where it is cultivated as a food crop. The Gofa, Konso, Burji, and Gamo tribes consume its leaves as a vegetable, especially during the dry season (Abuye et al., 2003; Demeulenaere, 2001; Jahn, 1991). *M. stenopetala* is native to Ethiopia, and it is known by various vernacular names. It is called "Haleko" in Gofa areas, "Shelagda" in the Konso language, and "Shiferaw" in Amharic (Engels and Goettsch, 1991; Jahn, 1991; Teketay, 2010). *M. stenopetala* is particularly important as human food because the leaves, which have high nutritional value (Abuye et al., 2003), appear towards the end of the dry season when few other sources of green vegetables are available. The leaves contain high amounts of essential amino acids and vitamins A and C (Abuye et al., 2003).

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Figure 1: *Moringa stenopetala* plant in the backyard of a farmer in southern Ethiopia

Despite its significant economic contributions to the livelihood of millions of people in southern Ethiopia, *Moringa stenopetala* has not been given due research and development attention. Thus, there is a need to popularize and promote this important but neglected indigenous vegetable tree. Therefore, the objectives of this paper are to review the actual and potential applications of *Moringa stenopetala* and to highlight the research gap and the way forward.

2. Description and Characteristics

M. stenopetala grows best in well-drained soils, and it does not grow in waterlogged or swampy soils (ICRAF, 2006; Steinmüller et al., 2002). It is a fast growing tree, well adapted to semi-arid areas with annual rainfall as little as 500 mm (Steinmüller et al., 2002). It is quite drought tolerant; however, it doesn't tolerate frost. It grows at an altitude ranging from 400 m to 2,100 m above sea level, an annual temperature ranging from 24-30°C, and an annual rainfall ranging from 500-1400 mm (ICRAF, 2006). *M. stenopetala* is a tree 6-12 m tall with a diameter of 60 cm and a smooth bark. Its pods are elongated, reddish with grayish blooms and twisted when the fruit is fresh (ICRAF, 2006). It has a white flower that attracts bees, and hence, is important in honey production. *M. stenopetala* is propagated both by direct sowing of the seeds without pretreatment and vegetatively using branch cuttings (ICRAF, 2006). The optimum temperature for the germination of *M. stenopetala* seeds was reported to be about 25°C (Teketay, 1995). *M. stenopetala* is an evergreen perennial plant (Figure 1) that can stay up to 60-100 years without reduction in productivity. *Moringa stenopetala* is more resistant to insect pests than other species in its family (ICRAF, 2006). However, it is affected by a caterpillar called *seexxe*, a general name for caterpillars that eat tree foliage (Demeulenaere, 2001).

3. Nutritional Value

Moringa tree has both nutritional and medicinal values. The leaves, flowers, and green pods of *M. stenopetala* are eaten as a staple vegetable and are rich in proteins and Ca, Fe, and P (ICRAF, 2006). *Moringa stenopetala* is a favorite and main component of the daily meal of the Konso, Gamo, and Gofa people in southern Ethiopia (Endeshaw,

2003; Personal observation). In the Konso area, Moringa leaves are eaten almost every day like spinach together with cereal balls (Steinmüller et al., 2002). It was reported that about 50% of the people in the Konso district of southern Ethiopia get their food from *M. stenopetala* (Endeshaw, 2003). People in the Gamo Gofa zone have a long tradition of consumption of *M. stenopetala*, locally called Haleko. In the lowland and mid altitudes of this region, it is hardly possible to find a household without a Haleko tree in his/her homestead. The leaf of the Haleko tree is eaten after cooking it like a cabbage. Haleko is particularly important as human food because the leaves, which have high nutritional value, persist throughout the year, including the dry season when few other sources of green vegetables are available.

Table 1

Proximate composition of raw leaves of *Moringa stenopetala*

Variables	(g/100g DM)[a]	(g/kg DM)[b]
Carbohydrate	51.8 ± 2.6	107 ± 4.2[c]
Protein	9.0 ± 0.7	282 ± 6.1
Fat	5.8 ± 1.4	84. ± 8.6
Crude fiber	20.8 ± 3.3	96 ± 7.9
Ash	12.6 ± 1.1	96 ± 7.7
Energy (Kcal)	295.4 ± 2.75	18.6 ± 0.18[d]

[a]Abuye et al. (2003); [b]Melesse et al. (2009); [c]This value is total sugar content of *M. stenopetala* leaf; [d]Gross energy is expressed in MJ/kg DM

Moringa leaves contain seven times the vitamin C of oranges, four times the vitamin A of carrots, four times the calcium of milk, three times the potassium of bananas, and two times the protein of yoghurt (Mathur, 2005). Moreover, Moringa leaves contain all the essential amino acids (Mathur, 2005; Melesse et al., 2009; Steinmüller et al., 2002) and vitamins A and C among others (Mathur, 2005; Steinmüller et al., 2002). Raw leaves of *M. stenopetala* contain 9% crude protein on a dry matter basis (Abuye et al., 2003) and a higher percentage of carbohydrates, crude fiber, and calcium (Table 1) compared to kale and Swiss chard (Abuye et al., 2003). Vitamins are present at nutritionally significant levels averaging 28 mg/100 g of vitamin C and 160 µg/100 g of beta-carotene (Table 2) (Abuye et al., 2003). Among the wide range of green leafy vegetables, Moringa is the richest source of beta-carotene (vitamin A) and provides other important micronutrients (Mathur, 2005). Minerals such as K, Fe, Zn, P, and Ca also exist in significant concentrations with average values of 3.08 mg/100 g iron and 792.8 mg/100 g Ca (Abuye et al., 2003). Reports indicated that given the high vitamin content, *M. stenopetala* leaves could be used to reduce child and maternal mortality rates in the country by 30-50% (Anon, 2003).

Table 2

Mineral and vitamin contents of raw leaves of *Moringa stenopetala*

Variables	(mg/100g DM)[a]	(g/kg DM)[b]
Minerals:		
Na	403.5 ± 21	4.1 ± 2.78
K	453.0 ± 11	16.6 ± 1.97
P	65.6 ± 13	3.8 ± 0.39
Ca	792.8 ± 92	18.5 ± 2.21
Fe	3.08 ± 0.8	-
Zn	0.53 ± 0.8	-
Mg	-	4.6 ± 1.1
Mn (mg/kg DM)	-	86.1 ± 6.96
Vitamins:		
Vitamin C (mg/100 g)	28.07 ± 7.3	
β-carotene (µg/100 g)	160	
α-carotene (µg/100 g)	54	
Retinol equivalent (RE)	34.04	

[a]Abuye et al. (2003); [b]Melesse et al. (2009)

Significant differences were observed in the proximate composition, mineral, and vitamin contents of the leaves of *M. stenopetala* reported by different authors in Tables 1 and 2. These variations may have been attributed to differences in the varieties used by these researchers. Different ecotypes and varieties of *M. stenopetala* are found in Ethiopia. A study conducted to assess genetic diversity of 19 *M. stenopetala* accessions collected from southern Ethiopia revealed the existence of genetic variability within and between populations (Beyene, 2005). Thus, there is a need to conduct detailed scientific studies to document the nutria-

tional composition of different varieties of *M. stenopetala*.

4. Physicochemical Properties of the Seeds

M. stenopetala seeds are triangular, have three wings, and are covered with a spongy, thick yellowish seed coat (Figure 2a). The kernel has a whitish-grey color and oval shape, and its thickness decreases from the center towards either end along the length of the seed (Figure 2b). It was reported that a single 4 to 13-year-old *M. stenopetala* tree can produce up to 4,500-10,000 seeds that weigh 2.3-5 kg from about 500-1,000 pods (Table 3) (EIAR, 2003). The same report indicated that 1 kg of *M. stenopetala* seed contains about 1,795-2,078 seeds.



Figure 2: The seeds of *Moringa stenopetala* (Seifu, 2012)

Table 3

Physical properties of seeds of *Moringa stenopetala*

Variables	Range[a]	Mean[b] ± SD
Average number of seeds/pod	9-10	-
Number of seeds/tree	4500-10000	-
Weight of seeds (kg)/tree	2.3-5	-
Average weight (g)/100 seeds (kernel + hull)	48.12-55.71	73.6 ± 2.28
Average weight (g/seed)	0.5	0.6 ± 0.02
Average weight of kernel (g/100 seeds)	-	59.6 ± 2.28
Kernel fraction (% of entire seed)	-	79.7 ± 0.95
Hull fraction (% of entire seed)	-	20.3 ± 0.95
Moisture of whole seed (%)	-	6.1 ± 0.24

[a]EIAR (2003); [b]Seifu (2012)

M. stenopetala seeds are reported to be larger than the seeds of *M. oleifera* (Mayer and Stelz, 1993; NRC, 2006). The average weight of undehulled seeds of *M. stenopetala* was found to be 73.6 g/100 seeds (Table 3). This is much higher than that reported (29.9 to 30.2 g/100 seeds) for *Moringa oleifera* seeds (Foidl et al., 2001). The average weight of the kernel (59.6 g/100 seeds) of *M. stenopetala* seeds is more than double the values reported (21.2-22.5 g/100 seeds) for *M. oleifera* seeds (Foidl et al., 2001). The kernel-to- hull ratio and the average weight per seed of *M. stenopetala* are 0.6 g and 79.7: 20.3, respectively (Table 3). The Ethiopian Institute of Agricultural Research (EIAR, 2003) reported an average weight of a single *M. stenopetala* seed to be 0.5 g. Reports indicated an average weight per seed of 0.3 g and kernel-to-hull ratio of 75: 25 for *M. oleifera* (Foidl et al., 2001). *M. stenopetala* seeds have an average moisture content (on DM basis) of 6.1 g/100 g (Table 3). This value is comparable to the corresponding values reported (5.70 g/100 g) for *Moringa oleifera* seeds (Anwar and Bhanger, 2003) and *M. concanensis* seeds (5.88 g/100 g) (Manzoor et al., 2007).

The gross composition of *M. stenopetala* seeds is indicated in Table 4. The average fat content (41.4 ± 1.59 g/100 g) (Table 4) of *M. stenopetala* seeds

is higher than 33.6 g/100 g and 27.5 g/100 g fat reported for the common oilseeds viz., flax seed, and safflower seed, respectively (Bozan and Temelli, 2008). *Moringa oleifera* and *M. concanensis* seeds contain 40.39 g/100 g (Anwar and Bhanger, 2003) and 38.82 g/100 g of fat (Manzoor et al., 2007), respectively. The seeds of *M. stenopetala* contain edible oil that can be used for cooking and as salad dressing. Lalas et al. (2006) reported that the oil extracted from *M. stenopetala* seeds does not deteriorate under a standard procedure used during extraction and has acceptable organoleptic quality. Similarly, Lalas et al. (2003) reported that *M. stenopetala* seed oil showed higher stability to oxidative rancidity compared to *M. oleifera* seed oil. Reports indicated that *M. oleifera* seed oil could be used for cooking, in salad dressings, and in the manufacture of perfumes and cosmetics (Jahn et al., 1986). Thus, it can be expected that *M. stenopetala* seed could have its own unique properties and possibly be used for similar purposes. To date, no study has been done on the oil production potential, characteristics, or applications of *M. stenopetala* seed oil in Ethiopia. Thus, this is one potential area of future research.

Table 4

Proximate composition (on dry matter basis) of seeds of *Moringa stenopetala*

Variables	(g/kg DM)[a]	(g/100 g)[b]
Fat	334 ± 14.3	41.4 ± 1.59
Crude protein	395 ± 8.4	42.6 ± 1.42
Ash	57 ± 2.8	4.6 ± 0.21
Crude fiber	96 ± 10.5	5.1 ± 0.27
Sugar	73 ± 1.8	-

Values are mean ± SD; [a]Melesse et al. (2009); [b]Seifu (2012)

The average protein content of *M. stenopetala* seeds was found to be 42.6 ± 1.42 g/100 g (Table 4), which is higher than the 33.25 g/100 g reported for *M. oleifera* seeds grown in Brazil (Oliveira et al., 1999), the 30.1 g/100 g reported for *M. concanensis* seeds grown in Pakistan (Manzoor et al., 2007), and the 22.1 g/100 g reported for *M. peregrina* seeds grown in Saudi Arabia (Somali et al., 1984). *M. stenopetala* seed meal obtained after oil extraction contains higher protein content (55.6 g/100 g) (Seifu, 2012). This suggests that *M. stenopetala* seed meal could be used as an important protein supplement in animal feeds, as is the case with its close relative *M. oleifera* seed meal (Foidl et al., 2001).

M. stenopetala seeds were found to contain average ash contents of 57 ± 2.8 g/kg DM (Melesse et al., 2009) and 4.6 ± 0.21 g/100 g (Table 4). These values are higher than the 4.43 g/100 g reported for *M. oleifera* seeds from Brazil (Oliveira et al., 1999) and the 2.5 g/100 g reported for *M. peregrina* seeds from Saudi Arabia (Somali et al., 1984). On the other hand, *M. stenopetala* seeds were reported to contain crude fiber contents of 5.1 ± 0.27 g/100 g and 96 ± 10.5 g/kg DM (Table 4). This is comparable to the crude fiber contents of 7.2 g/100 g reported for *M. oleifera* seed (Anwar and Bhanger, 2003) and 6.0 g/100 g reported for *M. concanensis* seeds (Manzoor et al., 2007). Dietary fiber plays a very important role in maintaining good health (Anderson and Bridges, 1988). The high crude fiber content of *M. stenopetala* seed analyzed suggests that it could serve as an important source of dietary fiber.

5. Antimicrobial and Medicinal Values

The leaves, roots, and seeds of *M. stenopetala* and *M. oleifera* have a long tradition of use in folk medicine. Various parts of the *M. stenopetala* tree are claimed to contain disease-preventing chemicals (Endeshaw, 2003). People with high blood pressure boil the leaves and drink the water to get relief from their aliment (Endeshaw, 2003). A recent report by Mengistu et al. (2012) indicated that *M. stenopetala* has blood pressure lowering effects. These researchers showed that crude aqueous leaf extract of *M. stenopetala* caused a significant drop in systolic blood pressure, diastolic blood pressure, and mean arterial blood pressure in normotensive anaesthetized guinea pigs.

Leaf extracts of *M. stenopetala* are used to lower blood glucose and cholesterol levels. Ghebreselassie et al. (2011) reported that aqueous leaf extract of *M. stenopetala* is shown to increase body weight and reduce serum glucose and cholesterol levels in mice. Serum glucose and serum cholesterol levels decreased significantly after six weeks of treatment. They indicated the need for further studies in order to fractionate the active

principle and find out the mechanism(s) of action of *M. stenopetala* leaf extract on blood glucose and cholesterol levels in animal models to ascertain its therapeutic importance. Similarly, experiments conducted on animal models showed that butanol fraction of the ethanol extract of *M. stenopetala* leaves has anti-hyperglycemic and anti-hyperlipedemic effects, and as a result, can be used to treat diabetes (Toma et al., 2012). These researchers indicated that administration of butanol fraction of ethanol extract of *M. stenopetala* leaves to diabetic mice resulted in significant reduction of fasting blood glucose level, serum total cholesterol, and triglyceride levels. The fraction also showed a tendency to improve body weight gain in diabetic mice. However, the mechanism of action of *M. stenopetala* leaf extract and the active principle responsible for the anti-diabetic effect are not fully understood and thus warrant further studies.

There are claims that the leaves of *M. stenopetala* boiled in water can cure malaria, hypertension, and stomach pain. The roots of *M. stenopetala* chopped and mixed with water are also used for treating severe cases of malaria (Mekonnen, 2003). *M. stenopetala* is also used as an herbal medicine in areas where visceral leishmaniasis prevails (Mekonnen, 2003). A recent report by Kinuthia et al. (2013) showed that methanolic extracts of dried leaves of *Moringa stenopetala* exhibit antileishmanial activity. They indicated that intra-peritoneal administration of methanolic crude extracts of *M. stenopetala* leaves into *Leishmania major* infected BALB/c mice lowered the amastigotes burden in their spleen. Similarly, a blend of *Allium sativum* and *M. stenopetala* methanolic crude extracts at a ratio of 1:1 significantly reduced the size of *L. major*- caused foot and pad lesions in BALB/c mice.

Ethanol extracts of fresh roots of *M. stenopetala* and acetone extracts of dried leaves showed activity against *Trypanosma brucei* with an ED_{50} value of 9.2 µg/ml and 10.0 µg/ml, respectively (Mekonnen et al., 1999). The essential oils of the seeds of *M. stenopetala* were found to have promising trypanocidal activity (Nibret and Wink, 2010). The essential oils of *M. stenopetala* seeds were dominated by isothiocyanates: benzyl isothiocyanate (54.30%) and isobutyl isothiocyanate (16.37%). The oil of *M. stenopetala* seeds and its main compound, benzyl isothiocyanate, showed the most potent trypanocidal activities with IC_{50} values of 5.03µg/ml and 1.20µg/ml, respectively.

M. stenopetala seeds also exhibit antibacterial properties. Eilert et al. (1981) reported that defatted and shelled seeds of *M. oleifera* and *M. stenopetala* contain 8-10% of an active antimicrobial agent. *In vitro* laboratory experiments showed that the seed extracts of *M. stenopetala* have antitrypanosomal and antimicrobial properties (Mekonnen, 2003). Purified fractions of leaves and seeds of *M. stenopetala* showed antibiotic activity against *Staphylococcus aureus*, *Salmonella typhi*, *Shigella* spp., and *Candida albicans* (Mekonnen, 2003).

Walter et al. (2011) reported methanol and n-hexane extracts of *M. oleifera* and *M. stenopetala* seeds as potential antimicrobial agents against some human pathogenic bacteria (*Salmonella typhii, Vibrio cholera,* and *Escherichia coli*) that are known to cause water-borne diseases. The result showed that the n-hexane extract of *M. stenopetala* had a higher inhibition on *S. typhii* than *V. cholerae* and *E. coli*. This finding shows that the seed extracts of *M. stenopetala* could be promising natural antimicrobial agents with potential applications in controlling bacteria that cause water-borne diseases. The extracts can provide a cheap and sustainable method of disease reduction in developing countries. However, safety and toxicity of the extracts need to be evaluated before using them to treat human diseases caused by these bacteria.

Recent findings indicated that the roots of *Moringa stenopetala* also have antibacterial properties. Tesemma et al. (2013) reported that acetone extracts of the roots of *M. stenopetala* showed antibacterial activity against the pathogens *Staphylococcus aureus*, *Salmonella* Typhimurium, *Escherichia coli*, and *Pseudomonas aeruginosa*. The active agents in the crude extract responsible for the antibacterial property were found to be cholest-5-en-3-ol, palmitic acid, and oleic acid. This justifies the traditional use of *Moringa stenopetala* for treatment of different bacterial infections.

Traditionally, *M. stenopetala* leaves are used to expel retained placenta from women (Mekonnen, 2003) and cows (personal communication), and the Turkana of northern Kenya make an infusion with

the leaves of *M. stenopetala* as a remedy against leprosy (Demeulenaere, 2001). The Njemps people of Kenya chew the bark of *M. stenopetala* as a treatment against cough and use the bark extracts to make fortifying soup (Demeulenaere, 2001). In Somalia, women inhale the smoke released by the burning of the *M. stenopetala* root during difficult labour (Demeulenaere, 2001). In the Konso district of southern Ethiopia, the same smoke is used as a treatment for epilepsy (Demeulenaere, 2001). The root extracts of *M. stenopetala* have traditionally been used to expel snakes from homesteads in the Gamo Gofa zone of southern Ethiopia (personal communication). The claimed, traditional medicinal uses of *M. stenopetala* deserve scientific investigation in order to verify the reported therapeutic values and evaluate its use in the pharmaceutical industry.

6. Economic Uses and Potential Applications

Every part of the *Moringa stenopetala* tree is utilized, and different parts (leaves, seeds, wood, and root) of the tree are used for different purposes.

Leaves:

Apart from being consumed as a vegetable, *M. stenopetala* is also marketed as a source of income in a local market in the Konso (Endeshaw, 2003) and Gofa areas of southern Ethiopia (Personal observation). *M. stenopetala* leaves and pods are used as fodder for animals (ICRAF, 2006). Melesse et al. (2013) reported that *M. stenopetala* leaf meal could be used as an alternative and inexpensive source of protein in the diets of grower Koekoek chicken breeds. They indicated that replacing roasted soybean with *M. stenopetala* leaf meal has resulted in general improvement of the growth performance, feed efficiency, and carcass yield of Koekoek chickens without affecting the vital organs. Gebregiorgis et al. (2012) reported that supplementing a basal diet of Rhodes grass hay with dried Moringa leaves improved dry matter intake, body weight gain, and nitrogen retention in sheep indicating that *M. stenopetala* can serve as a protein supplement to low-quality grass during the dry season under a smallholder sheep production system.

Seeds:

In addition to its antimicrobial properties, the seeds of the tree are used to clarify muddy water (ICRAF, 2006; Mekonnen, 2003). The seeds of *M. stenopetala* have natural flocculating and antimicrobial properties (ICRAF, 2006; Jahn, 1991). Earlier experiments showed that whole crushed seeds of *M. stenopetala* were effective in removing turbidity from waters with high initial turbidity, and bacterial contamination was reduced by 90 to 99.9% (Sutherland et al., 1989). *M. stenopetala* seeds have better water purifying properties than *M. oleifera* (HDRA, 2002). The active coagulating substances are found in the cotyledons of the seeds (ICRAF, 2006). A recent study (Hellsing et al., 2013) also indicated that proteins extracted from the seeds of the *M. stenopetala* tree are effective flocculent for particles dispersed in water and are attractive as a natural and sustainable product for use in water purification.

Moringa stenopetala seed powder could be used to remove heavy metals from water and industrial wastes. A study by Mataka et al. (2010) aimed at investigating the potential of *Moringa stenopetala* and *Moringa oleifera* for the removal of cadmium (II) ions from water indicated that *M. stenopetala* seed powder, at a dose of 2.50 g/100 ml, reduced the concentration of cadmium by 53.8%. Comparison of removal capacities between *M. stenopetala* and *M. oleifera* indicated that *M. stenopetala* was more effective than *M. oleifera* in removing cadmium from water. The results indicated that *Moringa* seeds could be used as a less expensive biosorbent for the removal of cadmium (Cd) from polluted water. Earlier reports indicated that *M. stenopetala* seed powder could remove lead from contaminated water (Mataka et al., 2006). These authors reported that *M. stenopetala* was more effective in removing lead from water than *M. oleifera*.

Another study indicated that *Moringa stenopetala* seed powder could be used to remove chromium (Cr) from tannery effluent (Gatew and Mersha, 2013). The results showed that *M. stenopetala* seed powder at a dose of 1 g/100 ml and pH of 9.5 decreased the concentration of Cr in tannery waste by 99.86%. A similar study by Degefu and Dawit (2013) showed that the seed powder of *M. stenopetala* was found to be effective in the removal of chromium from tannery wastewater. *M.*

stenopetala seed powder resulted in a 99.74% removal of chromium from tannery waste. The use of bioadsorbents like *M. stenopetala* seed powder that are easily available and effective for removal of heavy metals could be an innovative and economical approach for treatment of industrial wastewater.

The seed of *M. stenopetala* is an important source of oil that could be used for cooking or for different industrial applications. A recent report indicated that *M. stenopetala* seed oil could be used as a potential feedstock for biodiesel production (Ejigu 2010). The study indicated that *M. stenopetala* seeds yield 45% w/w of oil. The oil contains 78% mono-unsaturated fatty acid and 22% saturated fatty acid. Oleic acid is the dominant fatty acid and accounts for about 76%. When mixtures of alcohols were used, the amount of ethyl ester formed was 30% that of methyl ester. The recommended way to use the oil as a fuel is as a mixture of esters. This study showed that *M. stenopetala* has a number of advantages compared to biodiesel fuels derived from other vegetable oils. Moreover, *M. stenopetala* seed cake obtained after oil extraction contains high protein content and can be used as an important protein supplement in animal feed. A research finding also indicated that *M. stenopetala* seed cake powder can be used for biogas production (Mekete, 2008).

Roots:

In addition to the seeds, the roots of *M. stenopetala* can also be used to clarify dirty water. Nomadic peoples in the Omo Valley of Ethiopia apparently use the roots of wild *M. stenopetala* to clarify muddy water (Demeulenaere, 2001). The root is also used in traditional medicine to treat different aliments.

Wood:

Unlike *M. oleifera*, the *M. stenopetala* tree has soft wood and is not suitable for fuel but can be used for pulp production.

Whole Plant:

By virtue of its drought resistance, the *M. stenopetala* tree would help rehabilitate the ever-diminishing forest resources in drier tropical areas (Endeshaw, 2003). *M. stenopetala* also serves as a live fence and ornamental plant in its natural range (ICRAF, 2006). *Moringa stenopetala* is used in intercropping with other food crops (ICRAF, 2006), and it has no allelopatic effect. *M. stenopetala* has elongated roots that grow laterally and deep into the soil and, as a result, are important in soil conservation. It is also used as bee forage.

M. oleifera is used as a cleaning agent, fertilizer, gum, honey clarifier, natural pesticide, pulp for paper, and for making rope and tannin for tanning hides (HDRA, 2002; Fuglie, 1999). Given its close relationship to *M. oleifera*, *M. stenopetala* could possibly be used for all these purposes, and these aspects very well deserve detailed scientific investigations. In general, given its drought-tolerance, fast-growing habits, high nutritional value, potential to alleviate malnutrition in developing countries, and multitude of other uses, *M. stenopetala* deserves the name “the miracle tree of hope”.

7. Research Gap and Future Prospects

Despite its actual and potential roles, *M. stenopetala* has been given little attention. Unlike *M. oleifera*, little scientific research has been conducted on the potential uses of *M. stenopetala*. The limited research carried out so far has focused mainly on survey works conducted on the field to assess the traditional uses of *M. stenopetala* based on information obtained from Moringa growers. Even then, the survey results reported to date were conducted only at or in the vicinity of the Konso district of southern Ethiopia and are, as a result, far from complete. Since *M. stenopetala* grows in the Gamo Gofa, Sidamo, and Kaffa administrative regions of southern Ethiopia, more in-depth investigation needs to be undertaken in areas where it is domesticated and used in order to assess the various traditional uses of this important tree in different communities. Moreover, the claimed traditional uses of *Moringa stenopetala* need to be confirmed by scientific research, and its potential uses should be exploited.

The available research findings so far indicate that extracts from different parts of *M. stenopetala* have antimicrobial properties against a number of pathogenic bacteria. Moreover, experiments conducted on animal models demonstrated that *M. stenopetala* extracts have anti-diabetic and blood-cholesterol lowering properties. This shows the potential of the plant for developing drugs for

treating various illnesses in human beings. However, there is a need to conduct toxicity and safety tests on the Moringa extracts before using them in the pharmaceutical industry for drug production.

To date, no attempt has been made to select *M. stenopetala* and improve its agronomic traits, such as growth rate, yield, and pest and drought resistance. Thus, scientific studies need to be undertaken in order to identify the different varieties of *M. stenopetala*, to document the genetic diversity of the plant, and to improve the performance of the plant through breeding.

Although few studies conducted so far indicate the nutritional value of *M. stenopetala*, there is a need to determine the different macro- and micronutrients of the leaves and seeds of *M. stenopetala* and assess their nutritional, antioxidant, and functional properties. Moreover, use of Moringa in processing and new food product development deserves investigation.

8. Conclusion

Given its high nutritional value, drought tolerance, fast growth, and many of its potential uses, *M. stenopetala* should be given due attention by all concerned bodies and considered a priority crop to alleviate malnutrition and reduce poverty. Despite the enormous economic and social values *M. stenopetala* has among the rural community in southern Ethiopia, it has been given little research and development attention. Unlike *M. oleifera*, little scientific research has been conducted on the properties and potential uses of *M. stenopetala* in general and its seeds in particular. This calls for detailed and rigorous scientific study on *M. stenopetala* in order to fully understand the characteristics of the plant and exploit its full potential.

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