Commercialization of Moringa Production in Ethiopia:
Establishing Moringa Value Chain

Experiences and Lessons

Reviewers

Kaleb Kelemu
Girma Eshete
Busha Teshome

Sponsored by:
Austrian Development Cooperation

Proceeding of the 1st National Workshop on Commercialization of Moringa Production, June 4/2013, Hiruy Hall, Ethiopian Institute of Agricultural Research, Addis Ababa
Commercialization of Moringa Production in Ethiopia: Establishing Moringa Value Chain

Experiences and Lessons

Reviewers
Kaleb Kelemu
Girma Eshete
Busia Teshome

Sponsored by:
Austrian Development Cooperation

Proceeding of the 1st National Workshop on Commercialization of Moringa Production, June 4/2013, Hiruy Hall, Ethiopian Institute of Agricultural Research, Addis Ababa
# Table of Contents

1. Experience from Moringa Value Chain Development in Ethiopia  
   *Kaleb Kelemu*  
   Page 1  

2. Nutritional Profile of Moringa stenopetala Species Samples Collected from Different Places in Ethiopia and their Comparison with Moringa Oleifera Species.  
   *Abinet Tekle*  
   Page 21  

3. Processing methods, Nutritional and Medicinal Uses of Moringa  
   *Mulugeta Teamir*  
   Page 34  

4. Environmental, Economical use of Moringa stenopetala and its Cultivation Practice  
   *Girma Eshete*  
   Page 61  

5. Annexes  
   Annex 1: Minute of the Workshop  
   Page 80
Acknowledgement

We acknowledge the Gender Research Coordination Unit of the Ethiopian Institute of Agricultural Research, Rural Capacity Building Project (RCBP), and Agriculture Sector Support Project (ASSP) of the Oromia regional state, for financing implementing the Moringa commercialization project in Alamata, Shoarobit, Adama, and Yabello. Sincere thanks also goes to Austrian Development Cooperation of the Austrian Embassy in Ethiopia for the financing the first National Workshop on Moringa Commercialization, and publishing this proceeding.

Moringa Commercialization project Implementation Team
Welcoming Speech

Dr Wubahem Tadesse, Director, Forestry Research Directorate

On behalf of Forestry Research Directorate of the Ethiopian Institute of Agricultural Research (EIAR), I welcome you all to this important national workshop on ‘commercialization of Moringa Production’. The workshop aims at presenting and discussing on the outcomes of the Moringa commercialization project which has been implemented since the last five years in different parts of the country. The workshop is intended to share experiences and lessons learnt from moringa commercialization and to pave the way forward to strengthening the ongoing efforts and achieved outcomes so far.

As the aim of the workshop is to share experiences and lessons from our efforts in the process of commercialization of moringa in Ethiopia, various stakeholders from regional bureaus of agriculture and federal ministry of agriculture, research institutes, non-governmental organizations and producers and marketers of Moringa products are invited to attend the workshop. It is expected that four papers will he presented during the one day workshop and deliberations on the challenges encountered and key areas of emphasis that help strengthen the commercialization process will be the major areas of discussion.

It is my strong conviction that from the papers that will be presented and the experiences we have got from our commercialization project on moringa, you will get enormous lessons and contribute to jointly develop actionable recommendations that help strengthen Moringa value chain established throughout the country.

Finally I would like to extend my deepest appreciation for all of you for coming from distant areas and spending your precious time to attend the workshop. I would like also thank the Austrian development cooperation for financing the workshop. I, therefore; warmly welcome you all to this important workshop, and cordially invite Dr Adugna Wakjira, DDG, EIAR to officially open the workshop. Thank you!
Opening Speech
Dr Adugna Wakjira, Deputy Director General, EIAR

It is my great pleasure, to welcome you all to the first national learning and experience sharing workshop on ‘Commercialization of Moringa production’ jointly organized by the Ethiopian Institute of Agricultural Research and Austrian Development Cooperation. Ethiopian institute of agricultural research has been engaged in scaling up of technologies, knowledge and information to farming communities and other beneficiaries to contribute to the ongoing massive effort of reducing poverty and achieve food and nutrition security in the country. As part of our outreach interventions the experiences we have from commercialization of moringa production in different parts of the country has demonstrated remarkable achievements that have proved that technologies can really change lives of rural poor and give self-employment opportunities for citizens.

Dear workshop participants;
The institute through forestry research center has been introducing Moringa through a project called ‘Commercialization of Moringa production’ to rural and urban residents since the last four years in 4 major regions, Adama and Yabello (Oromia region); Kewet woreda (Amhara region); Arbaminch Zuria Woreda (SNNPR); and Alamata Woreda (Tigray region). Research have proved that Moringa is a tree which has enormous nutritional content with huge potential to address the prevailing food and nutrition insecurity problems of the country and it has been introduced by our institute as very crucial ‘food supplement’ as it posses various nutrients essential for human health. However, before the starting of the project 4 years ago Moringa has been a tree which has been consumed as a staple mainly in Southern regions particularly Konso, Gidole, Arbaminch and Wolaita areas. The areas on which moringa has been consumed at a staple was restricted only in these limited areas of the country. The project was started based on the assumption that if market is created through awareness creation and demand in different areas of the country, the expansion of such important tree would be facilitated
Dear Participants;
As a result various activities such as trainings, exhibitions of various food recipe and conferences were conducted in the above mentioned project areas and some urban areas to create awareness on importance, use and utilization of moringa. Because of our interventions the demand as well as the consumption of Moringa as food supplement is expanding at higher rate.

Dear participants;
Papers that will be presented on the workshop will show you the enormous nutritional content of Moringa based on the laboratory study/analysis made at Ethiopian health and nutrition research institute the sample of which were collected jointly with EIAR from different parts of the country. Findings of the most important studies conducted previously by many other researchers on the food, nutritional and health related benefits of Moringa will be presented. The experiences of many Africa and Asia countries that have done a lot on Moringa from establishment of big plantation up to industrial production of various Moringa products and benefit from export of the products will also be reflected on the workshop presentations. The project implementation was successful because of the Strong coordination of activities of the project; Effective monitoring of activities and target groups; strong functional linkages with local administrations, agriculture offices, women and youth affair offices, and other important stakeholders at different level in the target woredas.

Dear participants;
As the aims of the workshop are to share important findings on the nutritional benefits of Moringa; share experiences and lessons on the overall progresses and success of Moringa commercialization and value chain development; Discuss on the key challenges of ensuring quality and safety issues as market and consumption of Moringa is expanding at high rate in many areas of the country including Addis Ababa; set directions as to how the established moringa value chain would be strengthened while ensuring quality and safety issues; and deliberate on any other important issues that will arise during the workshop proceedings, you active participation throughout the workshop deliberation is very crucial.

With this remark, I wish you all have a fruitful deliberation and comfortable stay in the course of the workshop. Now I declare that the workshop is officially open. Thank you!
Experience from Moringa Value Chain Development in Ethiopia

Kaleb Kelemu and Busha Teshome
Forestry Research Center, Ethiopian Institute of Agricultural Research
Email: kaleb_kelemu@yahoo.com/kalebkelemuayele@gmail.com

1. Background

The roles of many tropical tree species and their products as sources of food, medicine and other services they provide to local people have been documented. The exploitation, uses and commercialization of these tree products, constitute an important activity for people living within, around and beyond forests in the region. Moringa is very much known in many parts of the world for its nutritious content containing several nutrients (essential amino acids, vitamins and minerals) that are necessary for healthy and productive life (Barminas, Charles, Milam and Emmanuel, 1998). The nutritional content makes it one of the best alternative commodity to ensure food and nutrition security. Despite its massive potential in addressing food and nutrition insecurity problems, Moringa has remained unutilized and neglected commodity in Ethiopia. Its use and level of consumption is very low and is restricted only in few areas of Southern regional state. Limited awareness on the importance of Moringa is the most attributable factor for its low level of use and consumption. As it possess most of the essential nutrients, it play vital role in curbing malnutrition problems persistent in many areas of the country. The Moringa tree species are increasingly becoming a valuable source of livelihoods for many people through household use and trading.

Benefits from forests, however, vary with households depending on their socio-economic characteristics (e.g. wealth status; family size in general and composition of female and male members in a household, gender and age of the household head)( Abebaw et al., 2012). Women are key role players in agricultural production, natural resource management and management of various enterprises run by farm households and households in urban settings. (Jones and Shaikh 2003) The role being played by women in the entire process of agricultural production, management of resources is fundamentally essential to ensure sustainability of the entire production system. The irreplaceable role they play in ensuring household food and nutrition security is also an important issue that needs to be well understood by practitioners involved.
changing people’s livelihoods. The market systems development, with its focus on facilitating access for the poor mainly women to markets and services, offers a powerful framework for addressing access barriers faced by women and girls and their by improve their economic wellbeing (Linda, 2012). Interventions that specifically target women to enhance their participation in income generation and self-employment schemes help increase their power and status, enhance their capacity to better contribute to the wellbeing of their families and improve food and nutrition security status of the household (Carr, 2004). In this regard, a project aimed at commercialization of Moringa production which targeted women as beneficiaries has been implemented by forestry research center of the Ethiopian Institute of Agricultural Research aimed at providing them with income generation and self-employment opportunities. The project was initiated to create wider awareness and demand on Moringa and promote its wider production and consumption.

Recognizing such enormous potential of Moringa, a project that aimed at commercializing Moringa production through establishing its value chain was implemented in Alamata woreda, of the Tigray national regional state, located 600 km North of Addis Ababa. Agro-ecological condition of the woreda is suitable for Moringa production and the Moringa tree is abundantly available throughout the woreda giving no benefit other than just serving as a shade tree. The woreda has no previous experience on utilization of Moringa, which is attributed to limited awareness on importance and enormous potential of Moringa to address many of the persistent problems prevailing in the woreda, i.e malnutrition, unemployment, limited opportunities for self-employment and income generating opportunities particularly for women. At present Moringa has become a good source of income and provided self-employment opportunities for many youths and farmers in Alamata woreda. The demand/consumption of Moringa products has substantially increased in different parts of Ethiopia, and supply of Moringa products from Alamata areas is increasing. The current price of one kilogram of Moringa in Addis Ababa market ranges between 140-300 Birr. The project is pronounced to be a successful project meeting all its predetermined objectives of commercializing Moringa production in Ethiopia.

This paper, therefore, presents the experience gained in materializing such enormous potential of Moringa by establishing and developing its value chain and integrating women in the entire value chain for their benefit.
Moringa stenopetala is often referred to as the African Moringa Tree because it is native only to Ethiopia and northern Kenya. Though it does grow in many other parts of the old- and new-world tropics, it is not as widely known as its close relative, Moringa oleifera. In Ethiopia, Moringa stenopetala grows wild in elevations between 1,000 and 1,800 m (3,000-5,400 ft), and it will grow as high as 2000 m (6,000 ft). Moringa foliage and fruit pods are rich sources of calcium and iron, and good sources of vitamins B, A, and C (when raw) and of protein (including goodly amounts of the sulfur-containing amino acids, methionine and cystine). M. stenopetala leaves are larger and more appealing in appearance than those of M. oleifera. Both young and older leaves are edible, though older ones are milder and more tender. They can be cooked in stews, soups, and stir-fries, or boiled as spinach. Young pods may be cooked, offering a flavor similar to asparagus. Immature seeds are often cooked and eaten as a fresh vegetable, while mature seeds can be dried and roasted. The flowers can be cooked or oven-dried and steeped as tea. Store dried leaves as future soup or sauce supplements. Blossoms are edible; they taste about like radish. Browning seeds from mature pods in a skillet, mashing them, and placing them in boiling water causes an excellent cooking or lubricating oil (very similar to olive oil) to float to the surface. The oil preserves well although does become rancid with age. Moringa foliage and fruit pods are rich in protein (including good amounts of the sulfur-containing amino acids, methionine and cystine) and good sources of vitamins A, B and C (when raw), calcium (Ca) and iron (Fe) (Ram, 1994). Many parts of the plant have been used in medicinal preparations traditionally in the region against malaria and internal parasites. The wood is very soft; useful for paper but makes low-grade firewood and poor quality charcoal. Attracting attention in recent decades is the use of the dried, crushed seeds as a coagulant in flood water purification (Jahn, 1984). Even very muddy water can be cleared when crushed seeds are added. Solid matter and some bacteria will coagulate and sink to the bottom of a container. Church World Service observed that powder from crushed Moringa seed kernels worked as a natural flocculent, binding to the solids in water and causing them to sink to the bottom. Since bacteria in water are generally attached to solid particles, treatment with Moringa powder can purify water with 90-99% of the bacteria removed. Additional treatment of the water by boiling or adding chlorine or bleach is needed to render it completely safe to drink.

In Ethiopia it is grown as a backyard crop in the southern parts of the Rift Valley and adjoining lowlands for its edible leaves, flowers and tender pods. The leaf of Moringa is very popular vegetable in Southern Nations and Nationalities and Peoples Regional State of Ethiopia and
valued for its special flavor. It is grown as backyard tree to make it accessible for daily use in
more than six million households of Southern Ethiopia (Endeshaw, 2003). Moringa has attracted
everseous attention of ethnobotanists and plant genetic resource conservationists due to its
widespread use in agriculture and medicine. Although Moringa is fast growing, drought tolerant
and easily adapted to poor soil and arid conditions, it has not received significant research
attention to select and develop potential ecotypes that might be valuable both as horticultural and
medicinal crops. Because of its multiple uses and easy of propagation and ability to thrive under
harsh environments, its acreage as a cultivated crop is on the increase, as is the demand for its
products. The cultivation of Moringa in Ethiopia occurs mainly in the Zones and Special districts
such as South Omo, Gamo Gofa, Kaffa, Sheka, Bench Maji, Wolaita, Dawaro, Bale, Borena,
Sidama, Burji, Amaro, Konso and Derashe (Edwards et al., 2000).

3. Benefits from Commercialization of Moringa

3.1 Meaning of Commercialization

Commercialization is the process or cycle of introducing a new product or production method
into the market. The actual launch of a new product is the final stage of new product
development and the one where the most money will have to be spent for advertising, sales
promotion, and other marketing efforts.

Commercialization is often confused with sales, marketing or business development. The
commercialization process has three key aspects:

1. The funnel. It is essential to look at many ideas to get one or two products or businesses
   that can be sustained long-term.
2. It is a stage-wise process, and each stage has its own key goals and milestones.
3. It is vital to involve key stakeholders early, including customers.

There are three levels of market orientation as far as food production systems are concerned,
according to Pingali and Rosengrant (1995 cited in Leavy and Poulton 2007:9). These three
levels are termed as subsistence systems, semi-commercial systems and commercial systems
based on the farm households’ objective for producing a certain crop, their source of inputs, their
product mix and their income sources. According to Govereh et al. (1999:5), “commercialization can be measured along a continuum from zero (total subsistence-oriented production) to unity (100% production is sold).” Strasberg et al. (1999) suggested a measurement index called household Crop Commercialization Index (CCI) which is computed as the ratio of gross value of all crop sales over gross value of all crop production multiplied by hundred (cited in Govereh et al. 1999:4). The advantage of using this approach is that it “avoids the use of crude distinctions as commercialized and non-commercialized farms” (Govereh et al. 1999:5). However, this index is not without its limitations. For instance, consider the case when a farmer growing one quintal of teff sells that all and another farmer producing ten quintals of teff sells only two quintals. The CCI will tell us that the first farmer is fully commercialized (100%) while the second is semi-commercialized (20%). This interpretation does not make sense in such circumstances. Even though this limitation of using CCI is worth noting, there is still some room to use it in practice especially in the context of developing countries where it is less likely to get smallholders selling all of their output and very large farms selling none of their output (Govereh et al. 1999).

As can be understood from the preceding discussion, the degree of participation in the output market is the conventional way to measure commercialization. However, Von Braun et al. (1994) provide other dimensions to the measurement of commercialization.

The benefits of commercialization are multifaceted. Von Braun and Kennedy (1994) state that commercialization plays a significant role in increasing incomes and stimulating rural growth, through improving employment opportunities; increasing agricultural rural productivity; direct income benefit for employees and employers; expanding food supply and potentially improving nutritional status. In most cases, these increased incomes have led to increased food consumption and improved nutrition.

Others look at the benefits of commercialization from the perspective of comparative advantage. According to Govereh et al. (1999), “commercialization increases productivity and income.” The basic assumption embedded in the comparative advantage is that farmers produce mainly high value cash crops which provide them with high returns to land and labor and buy household consumption items using the cash they have earned from cash crop sales (Govereh et al., 1999).

However, Govereh et al. (1999) warn that the previous assumption cannot work if the market for non-cash crops is constrained by “risks and high costs in the food marketing system.”
Smallholder agricultural commercialization is significantly related with “higher productivity, greater specialization and higher incomes.” It is stated that the aforementioned outcomes give way to improvement in food security, poverty reduction and economy-wide growth (Bernard and Spielman, 2008).

Several researchers indicate that the outcomes of commercialization depend on whether efficient markets exist or not. If efficient markets do exist, then commercialization leads to separation of production from consumption, supporting food diversity and overall stability at household level (Bernard et al., 2007:1) and increased food security and improved allocative efficiency at macro level. But if markets remain inefficient and transaction costs are high, smallholders fail to exploit the blessings of commercialization.

Samuel and Sharp (2007) pointed out that agricultural commercialization is a bridge through which smallholder farmers are able to achieve welfare goals. They describe farm household welfare to represent consumption of basic food (grains), high value foods (livestock products), expenditure on clothes and shoes, durable goods, education and health care. They also note that greater engagement in output markets would result in higher agricultural productivity which is, in itself, an intermediate outcome rather than a welfare goal. Nonetheless, agricultural productivity can facilitate the achievement of the welfare goals of small farms.

Various research undertakings reveal that the nutritional status of Moringa gives it high potential to address food and nutrition problems that is very much persistent in Ethiopia (Abuye and et al., 2007). The development of its value chain helps improve supply of various products of Moringa both in rural and urban areas so as to get the benefits of Moringa in addressing the food and nutrition security. The benefits that Moringa may provide can be classified into three categories.

3.2 Benefit to participating target groups (self-employment, increased income)

Self-employment and increased income are the direct benefits for targeted beneficiaries due to their involvement in Moringa value chain (Morris, M. 2001). Women integrated in Moringa value chain particularly in Moringa processing and marketing of various Moringa products help them earn substantial income. (Table 1) Average income earned by the women beneficiaries engaged in Moringa business is range from 1500-3000 Br/month and their income have shown tremendous growth during the last two years since they started the business. The
commercialization process and the development of its value chain provided more self-employment opportunities for a large number of unemployed citizens both in rural and urban areas.

Table 1: Average income per person by Moringa powder producers female groups

<table>
<thead>
<tr>
<th>Supply Period (Year 2011)</th>
<th>Amount of Powder Produced and Sold (Kg/person) (N=12)</th>
<th>Average income/person (N=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Quarter</td>
<td>24</td>
<td>1920</td>
</tr>
<tr>
<td>2nd Quarter</td>
<td>47</td>
<td>3760</td>
</tr>
<tr>
<td>3rd Quarter</td>
<td>62</td>
<td>4960</td>
</tr>
<tr>
<td>4th Quarter</td>
<td>91</td>
<td>7280</td>
</tr>
<tr>
<td>Total Average</td>
<td>224</td>
<td>17,290</td>
</tr>
</tbody>
</table>

3.3 Benefit to the entire society (Improved health, food and nutrition security)

The production as well as the consumption of Moringa is expanding in many areas of the country which is a direct impact of the project intervention and are growing at a higher rate during the last two years. As the level of awareness and subsequent consumption increase, the overall health status of the entire society will get improved. The feedback received from several individuals confirms that Moringa has a considerable impact on improving their health status. The increase in production of Moringa contributes to meet food and nutrition requirements of rural and urban communities. Increased consumption, particularly by children, prevents or reduces malnourishment problems persistent in many parts of the country. Expansion of Moringa plantation, which will take place following growing interest of farmers and private investors, the vegetation cover will be improved which adds value to environmental rehabilitation efforts going on in the country.

3.4 Benefit to the national economy (Long term)-Export earning

The benefit to the national economy through export earning is a long-term benefit that can be attributed to the project. Moringa is at present being traded in local markets. Various Moringa products unlike the situation three years ago have now become available in Addis Ababa Market.
This is made possible through the different sales point. This long term benefit will be made possible when large scale investment in Moringa production in the near future. Model value chain established will be strengthened and become functional to export various products as large scale investors enter into the value chain. This will be best facilitated when production and processing technologies are introduced in the entire value chain.

4. The Project Activities and Methodological Approach

The project is designed to commercialize Moringa production. It was designed based on the understanding that under utilization of Moringa is resulted from limited awareness on its importance. Such limited or no awareness among both in rural and urban communities has remained for long an attributable factor for non existence of market for Moringa as well as absence of its value chain in general. Farmers were not interested to grow Moringa tree because in the first place they were not aware of the importance of Moringa, secondly, if there was any aware famer, there was no market that may motivate him to grow Moringa. By taking the prevailing ground reality, the project was implemented to create awareness among the different segment of the society, to promote and develop production, processing and marketing system for Moringa. In so doing, the enormous potential of Moringa will be realized. The working assumption adopted that guide implementation of the project was that creating demand/market for Moringa among urban residents provide an incentive to farmers to grow Moringa. The other important assumption/principle adopted was that commercialization of Moringa take place at a higher speed if a value chain approach is employed with a particular emphasis on linking rural producers with urban consumers. The major methodological elements of the entire approach of the project are described below.

4.1. Establishing Model Value Chain: Strategic approach to commercialization of Moringa

Value chain approach has significant importance for commercialization of non-traded commodities. Commercialization of Moringa was made possible by applying a value chain approach. The approach identified three important stages the project has dealt with. These are production, processing and consumption stages. For a well functioning value chain each of the three stages must be well interconnected to ensure sustainable supply and flow of value added
product. It is a tedious task to establish a value chain from the scratch. It involved recruiting and training individual to play a defined role in the value chain. Under the project a group of farmers were selected to play a producers role and continuously supply raw Moringa leaf to Moringa processors- which is the next stage in the model value chain. They were regularly monitored to ensure that they are playing their role as required. A group of women unemployed youth were identified from the urban and peri-urban area and given intensive training on Moringa collection, drying methods, processing, packaging and marketing with all precautionary safety measures to be considered in the process. The Moringa processing groups were regularly monitored by the project staff. The processing groups play the most important role in the value chain and serve as a connecting bridge between producers and consumers. The third important stage in the value chain was the consumption stage. At this stage the project has identified two broader set of activities to be undertaken to facilitate the entire commercialization process. A serious of awareness creation activities were undertaken at different towns, for the case of this specific project, a serious of exhibition of various Moringa products were conducted by women groups. The exhibitions were conducted to serve a crucial objective of the project to create demand for Moringa products.
<table>
<thead>
<tr>
<th>Stages in Model Value Chain</th>
<th>Identified Actor</th>
<th>Purpose of the role</th>
<th>Institutional Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1: Production</td>
<td>Farmers/Investors</td>
<td>Ensure sustainable supply of Moringa products and ensure commercialization of Moringa production and consolidated value chain</td>
<td>Planting material supply</td>
</tr>
<tr>
<td>• Plant Moringa trees</td>
<td></td>
<td></td>
<td>Technical support</td>
</tr>
<tr>
<td>• Supply Moringa leaf</td>
<td></td>
<td></td>
<td>Monitoring of processes and outcomes</td>
</tr>
<tr>
<td>Stage 2: Processing</td>
<td>Female unemployed youth from urban and peri-urban areas</td>
<td>Facilitate market access to strengthen value chain and commercialization process</td>
<td></td>
</tr>
<tr>
<td>• Prepare Moringa powder</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Pack, advertise and retail Moringa powder</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage 3: Consumption</td>
<td>Mainly urban residents, students, business communities, opinion leaders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Purchase and consume Moringa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Disseminate information</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Simplified Chart of Value chain actor, their purpose and Intuitional support
Figure 2: A Simplified Map of Moringa Value Addition Steps/Process and Exchange Network

<table>
<thead>
<tr>
<th>Intervention Areas</th>
<th>Value Chain Actors</th>
<th>Value Addition Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Farmers</td>
<td>Growing Moringa trees and supply raw Moringa leaf</td>
</tr>
<tr>
<td>Training on importance and use of Moringa and Tree management</td>
<td>Women and unemployed Youth</td>
<td>Collection of Moringa Leaf (Green and healthy leaves)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Washing: removes all dust and other dirt materials from the surface of the leaf</td>
</tr>
<tr>
<td>Training on Moringa processing, packaging and marketing</td>
<td></td>
<td>Drying: Usually on a clean canvas and frequently turning/stir until the moisture is removed</td>
</tr>
<tr>
<td>Conduct awareness and demand creation activities</td>
<td></td>
<td>Remove impurities from the dried leaf, milling and sieving (Powder produced)</td>
</tr>
<tr>
<td></td>
<td>Urban residents</td>
<td>Packaging (Packaging can be done depending individual choice)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Retailers at Alamata</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Retailers at Addis Ababa</td>
</tr>
<tr>
<td></td>
<td>Consumption</td>
<td>(Consumers mainly at Addis Ababa and other towns)</td>
</tr>
</tbody>
</table>

Stage 1: Production

Stage 2: Moringa product flow

Stage 3: Moringa product flow
Demand Creation: Strategic Entry Point in Commercialization Process

After identifying the three stages, the critical challenge was where to start the intervention. Many projects failed when promoting commodities partly because they disregard the entire value chain, and rather focus only on part of the value chain (Jolly and Vijay 1997). The very success of this project is attributed to the fact that the entire value chain was targeted. The entry point to develop the value chain as a strategic intervention was to create demand for Moringa products before embarking on distributing Moringa seedlings. Two strategies were pursued to create demand for Moringa products. The first strategy was conducting a series of exhibition at different locations in urban areas. The urban areas selected for the exhibition are those areas where trader’s movement between such areas and rural communities in Alamata woreda is very high. Accordingly Alamata town itself and Mekele town were areas where series of exhibition were conducted to create demand among these towns residents. The second strategy was use of mass media to create demand among wider Ethiopia communities particularly in Addis Ababa. More than 2000 leaflets were distributed in Addis Ababa and information was disseminated through Ethiopian television and radio as a result of which the demand for such Moringa product has increased dramatically. The very strategic purpose of selecting consumption stage as entry point was to create initial demand for Moringa product to create initial interest among farming communities to grow and produce Moringa on their farms. This was done with the assumption that farmers do not grow a commodity that does not have market demand. The two strategies has created a substantial demand for Moringa products which inspired both farmers, female groups and other interested individuals to collect, process and supply Moringa product in response to the demand created. The growth trend Moringa powder supply based on one sale point in Addis Ababa market is presented on the figure 3 below.
The women groups established at Alamata woreda are benefiting from the increasing demand by supplying continuously Moringa powder in Addis Ababa market. Their supply capacity has also grown at a higher rate. Their supply capacity has increased during the last 4 quarter by 300%.

5. The need to Integrate Women as key value chain actor and Successes

The defining feature of cash crop production which involves production of commodities for market is that it entails engaging in output markets. This in turn depends on the ability to produce at scale, to achieve quality, and to secure low costs of transacting in markets (Ruth Vargas and Marcella Vigneri, 2011). Targeted women who were trained to produce Moringa powder were able to purchased fresh Moringa leaf from Moringa tree owners for wholesale and retail trade in a quantity that involves low cost and with the required quality. These female agents were relatively more mobile and were therefore able to connect to both rural communities (producers) and buyers in urban areas (consumption). This business model had substantial potential for rapid commercialization. The project targeted unemployed urban youth females and poor female residing in urban and peri-urban areas to engage in Moringa business. Their role as a linking agent between Moringa producers (rural) and consumer (urban) in the entire value chain was defined; hence they were trained by the project on all aspects of Moringa powder preparation,
packaging, and marketing. Integrating targeted women into the model value chain had involved rigorous task. Task of their integration was started by providing them intensive training on importance of Moringa, collection, processing and packaging as well as methods of advertising their product. They were also given training on safety measure to be applied when preparing Moringa powder. The targeted women were made aware of their role in the value chain to link rural production with urban consumption.

There were three reasons that justify the need to integrate women in the Moringa value chain through the project:

- Many of the tasks involved from collection up to delivery of final product to market are customarily roles of women. Many of these tasks are performed at home.
- Women are more efficient than men in preparation of Moringa products. As a result, women could have produced more than double within given period of time and a lot of wastage of Moringa leaf was observed among men, which increase their cost of producing a kilogram of Moringa.
- Women are disadvantage groups in a every community and by integrating them into Moringa value chain their economic status will be improved, hence contribute to reduce gender inequalities prevailing in the area.

6. Key Elements of Success Factors in Commercialization Process

6.1. Regular value chain monitoring

The activities and progress of the women groups in particular the information dissemination process had to be regularly monitored so as to ensure that the model value chain is operating as desired. The whole activities of the women group as well as the supply of fresh and processed Moringa products have been monitored every 15 days. The regular monitoring activities had served the following purposes:

- ensure/track expansion of demand for Moringa products through peer information exchange and various ways
- ensure value chain actors who were trained on various aspect of Moringa are playing their defined role. These include ensuring hotel and cafeteria owners are serving Moringa
tea, women groups are collecting, processing, packaging, and supplying Moringa powder continuously;

- ensure that support giving actors, such as woreda bureau of agricultures, municipality, and other relevant institutions who took part in the project are playing their role;
- ensure the linkage between producers (farmers who own Moringa tree) - Processors (women groups who are trained to collect, process and market Moringa powder) - Consumers (Urban residents) is strengthened so that the demand and well as supply of Moringa products are expanding.
- help identify gaps that need immediate correction measures or interventions and identify constraints that affect progress in the value chain development.

6.2. Proper documentation of available technologies and knowledge

Documenting important features of particularly underutilized and non-traded commodity that have potential economic value to the society is key factor of success in any commercialization process.

6.3. Continuous awareness creation for the available technologies

Awareness and demand creation is not a ‘one go’ practice particularly in interventions that aimed at commercializing underutilized non-traded commodities. Awareness creation activities have to be continuously planned and executed depending on the result obtained from regular monitoring activities.

6.4. Using Value chain approach and empowering the whole value chain

Looking into and working through the entire value chain was the key aspect of success in the Moringa commercialization process. The key aspect of establishing and empowering the whole value chain mainly focused on two aspects. The first is building the technical capacity of both chain and support actors. Chain actors’ capacity includes technical capacity in Moringa processing, packaging and overall entrepreneurship skills for processors and Moringa tree management. The second aspect is creating wider demand for the product and linking with local and terminal markets by creating awareness/demand mainly among urban residents. To ensure sustainability of the demand created and ensure continuous supply of Moringa products, and
ultimately to strengthen the Moringa value chain, the capacity of local value chain support actors drawn from different woreda offices was built through various mechanisms.

6.5. Alignment of both public and non-public development partners

The linkage and cooperation both in terms technical and resources between public and non-public development actors is very crucial for Moringa commercialization. This alignment is critical to ensure sustainable production and supply of Moringa products as well as sustained and co-ordinated intervention to successful commercialization in a wider scale. Such partnership is also instrumental to ensure institutional support to commercialization process and scale-up successes achieved at microenterprise level to nation-wide scale to move Moringa towards export sector.

7. Conclusions

- Value chain approach facilitates and speeds up commercialization of underutilized non-traded commodities.
- Value chain approach enhances the benefits to the poors and women in rural and urban communities.
- Apart from other methods such as leaflets, exhibitions and trainings, mass media should be intensively used in promoting unutilized agricultural or forestry commodities that can offer benefit to the society. Commercialization process is highly facilitated by use of mass media.
8. Recommendations

- As the model value chain will expand and link to various local and international markets, establishing a quality certification system is mandatory.

- The level of processing technology in use at present is very low, that the Moringa powder is being collected by hands, washed manually on big trays, sieved and dried on a clean bed sheet or canvases and converting it into powder using manually on wooden made grinder is very tiresome, that made mass Moringa production through such process is impossible. Such process not supported by technology has made the whole process labor demanding and the constraining the possibility of mass production.

- It is crucial to reorient agricultural technology transfer strategies into the one that embrace value chain approach.

- Intervention aimed at promoting Involvement of private investors is crucial for strengthening the model value chain established to further develop the chain from local to export market so as to earn foreign currency and promote Moringa as one of the contributor commodity for national economy.

- Production and distribution of Moringa seedlings has to be strengthened to consolidate the commercialization process.

- The experiences of other Asian and African countries have to be adopted particularly in processing and packaging aspects of Moringa products.

- Special program should be designed by regional agricultural bureaus to involve small-holders farmers and help them benefit from Moringa value chain. Their involvement can be both at production of Moringa and processing to supply at local market.

- Commercialization process particularly the production of Moringa should not only be left for small-holder farmers, but require large scale commercial farmers to sustainable supply the raw material for national and international market.
References


Nutritional Profile of Moringa stenopetala Species Samples Collected from Different Places in Ethiopia and their Comparison with Moringa Oleifera Species.
Abinet Tekle
Ethiopia Health and Nutrition Research Institute

Abstract
Among various types of Moringa species, Moringa stenopetala (M. stenopetala) is native to Ethiopia, Northern Kenya and Eastern Somali and is the most economically important species after M. oleifera. Moringa tree, well known as Shiferaw or Aleko in Ethiopia, is getting a great popularity although little is studied to understand its nutritional composition. Hence, this study has collected Moringa stenopetala (M. stenopetala) samples from 19 locations in Ethiopia to generate a national data on its nutritional profile. The fresh green leafy vegetables obtained from farming area in different provinces in Ethiopia were dried and physicochemical analysis was carried out employing standard methods of analysis. The samples collected had a mean value of 8.09%, 28.44%, 0.7%, 11.62%, 12.63%, 38.49%, 274 Kcal of moisture, protein, fat, crude fiber, ash, carbohydrate and energy respectively. Moreover, the samples had a mean value of 54.85 mg/100gm, 1,918 mg/100gm, 2.16 mg/100gm, 0.78 mg/100gm, 38.19 mg/100gm, 2,094 mg/100gm and 214.10 mg/100gm of Fe, Ca, Zn, Cu, P, K and Na respectively. The mean value of the anti-nutritional factors analyzed – phytate and tannin – was 378.44 mg/100gm and 358.89 mg/100gm, respectively. There has been a statistically significant difference in the mean values of all nutrition composition parameters between study regions – Tigray, Amhara, Oromia, SNNPR and Dire Dawa – except for tannin content of the samples. These finding reveals that M. stenopetala species of Moringa tree in Ethiopia has appreciable nutritional profile which can be of a great input to fight the long overdue malnutrition problem in Ethiopia.
1. Introduction

There are about 13 or more species of Moringa. Moringa species, *Moringa stenopetala* (*Moringa stenopetala*) is native to Ethiopia. Moringa tree is well known as Shiferaw or Aleko in Ethiopia. In Southern Ethiopia Moringa leaf is used as kale or cabbage for human consumption and animal feed. Leaf parts are promising as a food source in the tropics and according to the recent studies conducted by Melesse *et al.* (2009), moringa contains high amount of protein.

All parts of the tree except the wood are edible, providing a highly nutritious food for both humans and animals. The flowers are a good nectar source for honey and the seeds are a rich oil source for cooking and lubricant uses. Many parts of the plant have been used in medicinal preparations. Whole plants have been used as living hedges, fences, and windbreaks. The wood is very soft; useful for paper but makes low-grade firewood and poor charcoal. Attracting attention in recent decades is the use of the dried, crushed seeds as a coagulant similar to the chemical alum. Even very muddy water can be cleared when crushed seeds are added. In Ethiopia, *Moringa stenopetala* grows wild in elevations between 1,000 and 1,800 m (3,000-5,400 ft), and it will grow as high as 2000 m (6,000 ft). Light frosts will do it no harm. Freezes, though, may cause it to die back to ground level, where new sprouts may be produced. *M. stenopetala* is more drought tolerant than *M. oleifera*. Full sun is normal, though partial shade is tolerated. Plant seeds about 2 cm (1 in) deep in soil that is moist but not too wet. Sprouting occurs normally in 1-2 weeks. It can be allowed to grow for shade (6-15 m/18-45 ft), or kept low (about 1-1.5 m/3-4.5 ft) for easier harvesting.

The primary objective of the present research was to investigate the nutrients composed in Moringa leaves from different provinces in Ethiopia.
2. MATERIAL AND METHODS

Sampling

- Sample: *Moringa stenopetala* and *Olifera* leaves
- Study Area: 19 different places from SNNP (West Abaya, Arba minch, Derashy and Konso) Oromia (Adama, Dugda, loma and Yabelo) Amhara (Kewote, Dewa chela, Kallo and Bahir Dar) Tigray (Alamata, Mekele, Thahitay Kuraro and Humera) and Dere Dawa (Goro)
- *Oleifera* leaves collected from Oromia (Dugda and Loma)
- Sampling technique: purposive sampling
Study areas

ETHIOPIA
**Drying the Moringa Leaf**

1. Drying the moringa tree
2. Cut the branch and twigs
3. Stripping the leaflets and spread it on suit jute
4. Room Drying
5. Milling
6. Sieving and storing
Determination of Moisture Content

- Ash content determined by muffle furnace
- Crude fiber determined by acid-base digestion
- Fat was determined by acid hydrolysis method
- Crude protein: The crude protein content of the samples was estimated by Kjeldahl method.
- Determination of carbohydrate: Utilizable carbohydrate content was determined by difference
- Determination of gross energy: by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors; 4kcal/g for protein, 9 kcal/g for fat and 4 kcal/g for carbohydrates and expressed in calories
- Mineral determination: Fe, Zn, Ca and Cu by AA 6800
- Na and K was Determined by flame photometer
- P by the colorimetric method using ammonium molybdate
- Anti-nutritional factor
  - Phytate: Phytate was determined by the method of Latta and Eskin (1980) and later modified by Vantraub and Lapteva (1988).
  - Tannin: Tannin content was determined by the method of Burns (1971) modified by Maxson and Rooney (1972).

3. Result and Discussion

- The Proximate and Energy content of the dried leaf:
  - Moisture content, protein, fat, crude fiber, Ash, carbohydrate and Energy content
- Mineral content of the dried leaf
  - Fe, Ca, Zn, Cu, P, K, Na
- Antinutritional factors and molar ratios
  - Phytate, Phy:Fe, Phy: Zn, Phy:Ca and Tanin
- Statistical analysis and package used
  - SPSS, Version 17 for Microsoft
The workshop participant was agreed on EIAR to facilitate a workshop at national level to share experience and compile research activities in the country.

Finally certificate of recognition was given from D/Director of EIAR for those who engage on Moringa research, marketing and promotion activities.

1. Mr. Dechasa Jiru
2. Mrs. Mengiste Kindu
3. Mrs. Mulugeta Teamir
4. Dr. Senayit Yetneberk
5. Mr. Girma Eshet
6. Mr. Abinet Tekele
7. Ms. Abeba Kebede
8. Mr. Waleligne Ayano
9. Mr. Kaleb Kelemu
The Alamta Association said they began the work in November, 2002 after they took training on Moringa processing. Then they began to engage in small quantity. After the training they collect the leave without any cost from farmers tree in the area currently they paid for the farmers to collect Moringa leave. This shows that the awareness and importance of Moringa is growing in the area. Now the market is growing and expanding with this they get land from the woreda administrative to plant Moringa seedling.

From Amhara Research Center they give training on importance of Moringa for 300 farmers. The trainers also request to get manuals, leaflet for the development of Moringa. The research center suggests producing leaf lets, brochures from its establishment to management is important for the development and expansion of Moringa tree.

From Humera research centers they made a workshop that participate different stakeholders from farmers, local community and woreda administrative on promotion of use of Moringa as food.

The work related to Moringa is goes from non market product to market product with this I recommend the research should lead the development so we have to participate on this work from different research areas.

There was a suggestion EiAR should take the leader of Moringa promotion.

Banks are doing to support investors who involved on different sectors development bank is one of them and have a forestry sector which support investors who involved on with this recently Moringa is one of the sector supported by the bank. The bank need some information from the research centers on cost- benefit analysis (identifying basic parameters like yield/ha, year of harvest; for how many years.
Response: There are traders which involve in Moringa trade other than in associations and also in the free market economy if there are more consumers there is also new traders enter into market.

Question: Why women are less involved in wholesaler and export market product?
Question: Why Producers have less market margin?
The market is not competitive there are limited producer/retailer –many consumers

PART II: General Discussion

In shewarobit there was a workshop in 2001 after this there is a huge difference in involvement of people, now days many farmers have Moringa plantation in their homestead. The number of seedling grows in the woreda agricultural office increase over time:

2001- 20,000 seedling
2002- 50,000 seedling
2003- 100,000 seedling
2004- 120,000 seedling

For direct sawing we prepared for about 5 quinatls of seed in 2004.

How do you see the cultural resistance when considering Moringa as food security in the community?

➤ Before the workshop in 2001 in shewarobit the tree was not considered as food but after training it is used as food the shoot fresh taste as milk. In our area those certified people are producing this product.

How the showarobit and Alamata farmers are using Moringa are they use for market only or use for their own consumption?

➤ Promotion of Moringa was began in Showaribit and Alamata by giving training to the society how they use for their own consumption with this the society use for their own consumption and market.

How much doze of Moringa is recommended to take? To answer this and other researchable areas we will began to collaborate with offices like Pastor.

➤ Experience from Adama Cassava and Moringa scale up project shows that: Once the husband was in conflict with his wife for why she use Moringa in the house however after some time he also interested on it and now he also take Moringa.
Comment: In your review it is better to assess detail information related to your title to indicate research gaps.

Comment: In your recommendation I found some are not came from your result section recommendations should not disconnect from result.

Comment: Papers show us from the utilization side of Moringa, the development and management activities also should be considered.

Question: Why population status of moringa was not studied in our country?

Presentation title: Experiences from approaches in commercialization of Moringa production and market linkages for Moringa in Ethiopia

By: Kaleb Kelemu

Question: You started commercialization in areas where it is not known what you did to make competitive production?

Response: Some years ago moringa was not a traded product and except few researchers peoples were not interested. Considering this, the project was begun by resource mobilizing from different sources. Then we have begun to work on creating market particularly in terminal markets.

Question: How your exit strategy for the project? How monitor the project?

Question: How much the supply satisfies the demand?

Response: To balance demand and supply side we did not deliberately advertise in Addis Ababa. The present demand is enough for farmers to plant and produce Moringa.

Question: Which niche is preferred to plant Moringa (homestead, agroforeststry, and plantation).

Response: Moringa can be planted in all areas.

Comment: In your value chain the input segment was missed

Question: When it began to give yield after planting?

Response: It can be harvested twice a first year 1/2kg per tree in intensively managed plantation.

Question: Why other society is not involved in Moringa trade than those in associations?
**Presentation title: Health and Nutritional benefits of Moringa**

**By: Mulugeta Teamir**

**Question:** In terms of what Moringa treat water? Is it treating bacteria or other?

**Response:** Regarding the water purification there are articles which contradict on curing bacteria some wrote as it purify water from bacteria others wrote it did not purify, with this I prefer not to take any side.

**Question:** From practical point of view vegetables like cabbage is used when they are fresh if Moringa is used after drying how this is?

**Response:** I recommend using Moringa its fresh leaves while the drier is preferable to use at any time when we need it.

**Question:** What is the purpose of the research review?

**Response:** Ethiopia is one of the countries where malnutrition problem is high with this consideration Moringa is one of the trees species which have nutritional value so this review showed the importance of Moringa in solving malnutrition problem.

**Question:** How could you identify the pure Moringa powder from other mixed powder in market?

**Response:** To stop the mixed Moringa powder giving certification system for pure Moringa producers should be developed.

**Question:** What packaging material is recommended for Moringa?

**Response:** For Moringa powder a paper foil is recommended.

**Presentation title: The potential contribution of Moringa for Agro forestry**

**By: Girma Eshete**

**Comment:** The disease which you showed as was not caterpillar rather leaf miner.

**Question:** What prototype mean in your recommendation?

**Response:** In Moringa processing there is a problem of material which increase the efficiency of the producers with this prototype is necessary.

**Comment:** From the review Moringa is better in carbon sequestration than Japanese Cedar however to come up with this I recommend to compare Moringa with the REDD+ species.
Annexes

Annexe1: Minute of the Workshop

PART I: Paper Presentation

Presentation title: Nutritional Profile of Moringa, based on samples collected from different locations in Ethiopia

By: Abinet Tekle and Adamu

Question: If Moringa is recommended as nutritional value which part of the tree is used?
Response: A research will be conducted on physiological aspect of the species to recommend which part of the leaf and time of harvest is more nutritional value.

Comment: It is difficult to compare the species that grow in different environment with one way Anova since Anova is used to compare when the variables are grown in the same unit.

Comment: Diversity analysis research should be conducted to select species.

Comment: Your research methodology showed that you conduct in four regions and collect the samples from this area rather it is good to collect the sample from different part of the country.

Comment: It is recommended to increase the total sample size of the species which you used for data analysis.

Comment: When you analyze the data it is better to use altitude/ soil type /climate of the study area rather than analyzing region by region.

Question: How could you analyze the data, is that by region or species level?
Response: we analyze the data in both by region and species level.

Question: You said that Moringa is nutritional values however other institution like DAKAR has another perspective how did you compromise their view?

Comments: As this is a preliminary work we appreciate the research team and suggest them to incorporate other experts from different disciplines like agronomists, feed scientist as they know the sample determination methods and also to identify and recommend parameters to be taken. Collaboration with other partners like MSc and PhD student is also relevant.
Reference


Conclusion

*Moringa stenopetala* is now regarded as one of the most promising crops in the country. This leafy green has been considered as a wonder tree next to coffee and became the "it" vegetable in no time. Cultivation and processing of *Moringa* greatly expanded in the recent years to supply the emerging local and international markets. There is also a widening interest among farmers on its global opportunities, but there is a need for farmers especially on the technical parameters and requirements that come with *Moringa* cultivation and research to investigate the growth habit, ecological optimum, the influence of the species on microclimate, and on other cereal crops when agroforestry practice particularly special project should be made for commercial production of food product, neuroceuticals, *Moringa* oil (edible as well as cosmetics), fortified feed for cattle, biogas, and plant fertilizer. Also, the food and medicine sector should focus their study on the species nutrient bio-availability and bio-toxicity, positive effects on the immune system in fighting diseases, such as: malnutrition, HIV/AIDS.

*Moringa* tree could easily and cheaply be cultivated and grown in Africa. The poor countries such as Ethiopia should design and develop strategy to promote planting and use of *Moringa* on war footing in order to explore and utilize full benefits of this miracle tree instead of waiting for bounties of food relief from the rich west.
eventually will dominate the site. Incorporating moringa leaves into the soil before planting can prevent damping off. The bark of the tree can be beaten and changed into a fiber for rope or mat production. The bark and gum can be used in tanning hide.

6. Moringa’s Potentials and Climate Change

One practical step to compensate for the several unpreventable carbon dioxide emissions is to plant trees. This is because trees take carbon dioxide out of the atmosphere and release oxygen in return. The type of trees planted will have a great influence on the environmental outcome. According to a Japanese study (Villafuerte, and Villafurte-Abonal, 2009) the rate of absorption or assimilation of carbon dioxide by the moringa tree is twenty times (20x) higher than that of general vegetation and fifty times (50x) higher when compared to the Japanese cedar tree. The moringa tree therefore will be a useful tool in the prevention of global warming in that, one (1) moringa tree will be equivalent to the effectiveness of fifty (50) Japanese cedar tree in absorbing carbon dioxide (Villafuerte, and Villafurte-Abonal 2009). For example, If we expanded moringa from one hundred thousand (100,000) hectares worldwide to one million (1,000,000) hectares, that would equate to five (5) gigatonnes of CO2e being sequestered.

The future research focus should be:

- Genetic Improvement Almost certainly moringa can be selected and improved in ways that produce separate cultivars for top-quality vegetable
- Genetic Diversity This immensely useful tree’s genetic variability needs careful assessment. Although many types exist, no one presently knows which are best suited to various uses, environments, and local needs
- Development of seed orchards of improved material for specific purposes and end uses
- Enriching germplasm collection and conservation
- Development of value added moringa products for export
Using Moringa stenopetala to purify water replaces chemicals such as aluminum sulphate, which are dangerous to people and the environment, and are expensive. Twenty litres of water may be purified by adding 2 grams of powder to one cup of clean water, pour into a bottle and shake for 5 minutes. Filter the solution through a clean cloth into the bucket of dirty water that is to be treated. Stir the water quickly for 2 minutes and slowly for 10 to 15 minutes (do not use metal implements).

**Traditional Medicine**

Every parts of the tree is widely used to make a wide variety traditional medicine. Moringa stenopetala micronutrient liquid, a natural anthelmintic (kills parasites) and adjuvant (to aid or enhance another drug) is used as a metabolic conditioner to aid against endemic diseases in developing countries (Foidle et al., 2001) passed down for centuries in many cultures around the world, for skin infections, anemia, anxiety, asthma, blackheads, blood impurities, bronchitis, catarrh, chest congestion, cholera, conjunctivitis, cough, diarrhea, eye and ear infections, fever, glandular, swelling, headaches, abnormal blood pressure, hysteria, pain in joints, pimples, psoriasis, respiratory disorders, scurvy, semen deficiency, sore throat, sprain, tuberculosis, for intestinal worms, lactation, diabetes and pregnancy. The healing properties of Moringa oil, have been documented by ancient cultures. Moringa oil has tremendous cosmetic value and is used in body and hair care as a moisturizer and skin conditioner. Moringa oil has been used in skin preparations and ointments since Egyptian times.

5. Other Uses of *M. Stenopetala*

Moringa seeds contain between 30-40% oil, with 13% saturate fats and 82% unsaturated fatty acids. About 65-73% of moringa oil is oleic acid with olive and sunflower oils having 75% and 40% respectively. Just like olive oil, moringa oil contains 1-2% of beneficial essential fatty acids such as omega 3 and omega 6 (Villafuerle, and Villafurte-Abonal 2009). The oil can be used for cooking, as lubricant in fine machinery and as fuel lamps and in the manufacture of soaps, perfume and hair care products. Potentially there is profit in moringa. First, this is a fast-growing, high-yielding oilseed. Second, the trunk is gaining importance as a raw material for papermaking. And third, pods can be produced for the fresh market or for processing. This species is able to thrive in wastelands and provide rapid shade cover could make it the choice for many tree-planting projects. Likely, too, it is a good nurse crop for slower-growing species that
dietary minerals, especially calcium (up to about 2000 mg) and iron approaching 30 mg, about
twice the level of spinach and exceeding even the amount in patent medicines touted for
stimulating pep and vigor.

Pods On a dry-weight basis the protein content of moringa pods ranges from 20 to 30 percent—
an amount well above average for a vegetable. Moreover, vitamin C content is so high that a 50 g
serving (or less) provides an adult’s daily needs. In addition, minerals seem to be in good
proportion. Iron—often deficient in African diets—is as high or higher in the pods than in the
leaves, although the level probably depends on site conditions and preparation. The content of
copper also seems notable (though highly variable and requiring confirmation).

Seed Oil The liquid making up a quarter to almost half the seed’s weight is not unlike olive oil in
composition. In one analysis of the fatty acids, the seed oil contained about 66 percent oleic, 9
percent palmitic and behenic, and 7 percent stearic.13 The nutritional contribution of the oil itself
to meager diets could be significant.

Moringa stenopetala and livestock
Moringa stenopetala produce an excellent fodder as has been reported by many authors. tree is
with a great indigenous source of highly digestible proteins, Ca, Fe and multivitamins. Which are
essential for livestock for weight gain and increase in milk production .Leaves are readily eaten
by cattle. Sheep, goat, can also be used as food for fish.

Water Purification
Million people in Ethiopia are estimated to rely on untreated surface water sources for their daily
water needs. Of these, some of are thought to die from diseases caught from contaminated water
every year, with the majority of these deaths occurring among children under five years of age.
Powdered seed act as a natural flocculent, able to clarify even the most turbid water Seed powder
can be used as a quick and simple method for cleaning dirty water. The powder joins with the
solids in the water and sinks to the bottom.

This treatment also removes 90-99% of bacteria contained in water, water purification by
flocculation, sedimentation, antibiosis and even reduction of Schistosome cercariae titer.
Recycling of nutrient to the soil

The deep root systems of *M. stenopetala* bring important quantity of minerals from depth to enrich the surface layer through litter fall. The mineral elements are returned to the soil in fruit, dead wood, decomposition of roots. The seed cake although unsuitable as animal feed without treatment to remove the alkaloid and saponin content can be used as nitrogen-rich plant fertilizer.

Use as Plant Growth Enhancer

*Moringa* leaf extract is best used as Plant growth enhancer; Lab experimentation had shown that *Moringa* spray had a wide range of beneficial effects on plant crops. The *Moringa stenopetala* tree is a source for natural plant growth stimulators. Specifically, *Moringa* leaves contain healthy amounts of cytokines, which are naturally occurring plant hormones. Cytokinins stimulate cytokinesis, or cell division, in the shoots and roots of plants. Effects of spray result accelerated growth of young plants. Plants were firmer, more resistant to pests and disease. Longer life-span, heavier roots, stems and leaves, produced more fruit, larger fruit, increase in yield 20-35%. If even a fraction of these results could be reproduced in the field, it could be a great help in increasing food supplies for millions of hungry people.

*Moringa stenopetala* Rich of Nutrients

Most parts of this plant are more than just edible; they are nutritious. *Moringa*, unlike most foods in this report, has been analyzed in many studies that support high (though highly variable) levels of carbohydrate, protein, and especially vitamins and minerals. It has been said, for example, that: “As sources of the usually short sulfur-bearing amino acids methionine and cystine. *Moringa oleifera*, grown for edible leaves, shoots, young fruits, and roots, is incomparable. Methionine and cystine are arguably the most critical dietary ingredients for people lacking regular access to meat, milk, cheese, eggs, or fish.

Leaves are eaten fresh or dried as a storable powder (in which process they can lose much of their vitamin C). On a dry-weight basis, both have more than 200 calories (up to 400 is reported), with about 30 percent protein and 1-2 percent fat. Nutritional trials with laboratory rats show that the leaf is an excellent supplement to rice and other staples. In addition to being rich in overall protein these leaves also, as noted, provide methionine and cystine. A modest helping (100 g dry-weight) generally provides at least an adult’s daily requirement for pro vitamin A. The leaves are also supply good folate and other B vitamins. Further, they are among the best plant sources for
4. *Moringa Stenopetala* and Agriculture

The tree is good in agro-forestry and mixed cropping. The thin shade helps protect vegetables in the hot tropical sun. Because of its downward rooting pattern, there is little competition with associated crops. This seems to have the making of an ideal Agro-forestry component.

**Intercropping**

*Moringa stenopetala* is a farmer friendly plant and strongly recommended for Agro-forestry because it does not have any negative effect on crops since it is minimal shade deep rooted few lateral roots and does not compete with crops for soil nutrition. It helps to improve organic matter in soil and ultimately the soil fertility. Traditionally, the species can be sown in alleys and associated with other crops. The distance between *moringa* rows must be 2 to 4 meters, and they must be oriented East-West to ensure that intercrops receive enough sun.

Farmers practice permanent cultivation with *M.stenopetala* in mixed multi-story stand with food crops. At the uppermost level, Papaya, Coffee and Bananas in the middle level; Cassava Maize and Sugarcane in the lower middle level Cotton and Pepper in the lowest level. But it is advisable to avoid associating *moringa* with crops that require a lot of nitrogen (Maize, cassava).

**The Effect of Moringa stenopetala on Soil Fertility**

Moringa leaves can be easily processed for their concentration of cytokinins to replace chemical fertilizers which are harmful to the long-term health of soil. It is important that these simple advances in farming technology continue to spread throughout the developing countries whose livelihoods depend on agricultural exports will benefit greatly from small advances in agricultural innovations and natural alternatives to industrial farming practices. Moringa’s natural plant growth hormones have the potential to help these developing countries create more sustainable and productive agricultural growth and reduce dependence on chemical additives on their farms.

**Organic soil characteristics**

The soil feature greatly influenced by the presence of *M.stenopetala* in farm land. This is mainly due to the organic debris from the tree (twigs, Leaves and pods). The Agricultural crops which grow better in the mixture of *M.stenopetala* than agricultural land without *moringa*. It can fit very well as a candidate crop for organic cultivation and also can concluded that organic *M.stenopetala* production is feasible and is sustainable economically as well as socially in the present context of reducing pollution of natural resources and cost of farm production.
Insects
The most common pests are grasshoppers, crickets and caterpillars. These insects bite and chew parts of the plant, causing the destruction of leaves, buds, flowers, shoots, fruits or seeds as well as the interruption of sap flow. These outbreaks are frequent in dry zones where moringa leaves strongly attract by insects. It seems that these outbreaks occur at the beginning of the dry season when insects cannot find other tender, green material to feed on. The best solution, in this case, is to cut back the trees, leaving no green part apparent. The following growth is very vigorous if conditions permit (sufficient water supply). Concerning the Lepidoptera caterpillar, it is imperative to detect the outbreak at the beginning, at the shoot centre, in order to act before it is too late. Spraying must be aimed at the centre and the extremity of the shoots to reach the young caterpillars.

Fungal diseases
These diseases are by far the most serious in moringa farming. Brown spots can appear on the leaves and then spread to cover them entirely, turning the leaves yellow and killing them. This is caused by the fungi Cercospora spp and Septoria lycopersici. Alternaria is also frequent: angular, dark-brown spots with concentric circles appear on the leaves. Black or brown marks appear on the branches as well. The fungus is known as Alternaria solani. The onset of the disease is hard to detect. Once the spots have appeared it is often too late to treat and defoliation is inevitable. It is therefore important to remember the periods when the symptoms appeared to be able to act earlier the following season. The effective, inexpensive products to use in both cases are made from either mancozeb or maneb. The area around the trees, in organic farming, should be kept clear of weeds which are often hosts to diseases. The leaves and young shoots should be checked regularly for symptoms of fungal attacks. An early detection will save a lot of young plants from destruction. Neem leaf or seed extract can be sprayed on the plants to control pest and fungal attacks. This treatment is not as effective as using chemical products. The neem extract should be used as early as possible and sprayed repeatedly. Neem products can be produced locally and are not toxic for humans. The leaf extract is not as effective as the seed extract, but it can be used as well.
the soil as they decompose. Burying plant residues must be especially avoided on sloping terrain; to limit soil erosion. Weeding must be done early enough so that no seeds develop on the weeds. If fruits and seeds are present, weeds must be removed from the field.

**Mulching**

Mulching consists in covering the soil with crop or weed residue to reduce the loss of soil moisture and to minimize irrigation needs during the dry months. This also reduces Weed growth.

**Harvesting and Handling**

The tree withstands heavy cutting and can provide a continuing supply of wood, fodder, and other products. Both coppicing (continual cutting near the base) and pollarding (continual cutting higher up the trunk) are possible. One recommended system is to set the trees about a meter apart and trim them regularly like a hedge to provide successive crops of leaves. For making leaf sauces, harvest seedlings, growing tips or young leaves. Older leaves must be stripped from the tough and wiry stems. These older leaves are more suited to making dried leaf powder since the stems are removed in the pounding and sifting process. When harvesting pods for human consumption, harvest when the pods are still young (about 1cm in diameter) and snap easily. Older pods develop a tough exterior, but the white seeds and flesh remain edible until the ripening process begins.

When producing seed for planting or for oil extraction, allow the pods to dry and turn brown on the tree. In some cases, it may be necessary to prop up a branch that holds many pods to prevent it breaking off. Harvest the pods before they split open and seeds fall to the ground. Seeds can be stored in well-ventilated sacks in dry, shady places.

**Pest and Disease control**

*Moringa stenopetala* is more resistant to insect pests than other species of its family. Most farmers in its natural range report that they never saw diseases or pests on this tree. On deep generic ferrasols, the seeds have been found to be attacked by insects after sowing. And in very water-logged conditions, Diplodia root rot can occur.
After the initial pruning to shape the trees maintenance pruning is required. This can be done at each harvest, if the leaves are removed by cutting all the stems above a certain height. If leaves are harvested by plucking, or if the trees are left unharvested during the dry season, the bushy shape can be lost and a good pruning must be done at the onset of the rainy season. If the main stem is too thick, terminal branches can be cut down as in the initial pruning. In any case, it is important to cut just above a node to reduce rotting of terminal parts. In seed-producing farms, pruning helps induce more fruits, as well as larger fruits. Break the terminal bud when the plant is about one meter high to stimulate branching.

**Watering**

Moringa trees do not need much watering. In very dry conditions, water regularly for the first two months and afterwards only when the tree is obviously suffering. Moringa trees will flower and produce pods whenever there is sufficient water available. If rainfall is continuous throughout the year, Moringa trees will have a nearly continuous yield. In arid conditions, flowering can be induced through irrigation.

**Fertilizing**

Moringa trees will generally grow well without adding very much fertilizer. Manure or compost can be mixed with the soil used to fill the planting pits. Phosphorus can be added to encourage root development and nitrogen will encourage leaf canopy growth. In some parts of the world 15cm-deep ring trenches are dug about 10cm from the trees during the rainy season and filled with green leaves, manure and ash. These trenches are then covered with soil. This approach is said to promote higher pod yields. Research done in India has also showed that applications of 7.5kg farmyard manure and 0.37kg ammonium sulfate per tree can increase pod yields threefold.

**Weeding**

Manual weeding with a hoe removes weeds and loosens the soil for good aeration. Weeding must be done regularly to avoid competition for nutrients, especially for nitrogen. If not weeded properly, the trees produce fewer leaves and the leaves at the base of the plant begin to yellow. Weeding must be more frequent when the plantation is young and the trees are small, allowing light to reach the soil. It is advisable to weed an adult plantation at least 4 times a year, with a higher frequency during rain seasons. A good option is to leave the weeds on the soil as a mulch to reduce evaporation and enrich the soil. Burying them is not necessary as tropical soils have a very low capacity to retain minerals over time. It is better to let the weeds progressively enrich.
Growing from cuttings

Use hard wood, not green wood, for cuttings. Cuttings should be 45cm to 1.5m long and 10cm thick. Cuttings can be planted directly or planted in sacks in the nursery. When planting directly, plant the cuttings in light, sandy soil. Plant one-third of the length in the ground (i.e., if the cutting is 1.5m long, plant it 50cm deep). Do not over water; if the soil is too heavy or wet, the roots may rot. When the cuttings are planted in the nursery, the root system is slow to develop. Add phosphorus to the soil if possible to encourage root development. Cuttings planted in a nursery can be out-planted after 2 or 3 months.

Spacing

For intensive Moringa production, plant the tree every 3 meters in rows 3 meters apart. To ensure sufficient sunlight and airflow, it is also recommended to plant the trees in an east-west direction. When the trees are part of an alley-cropping system, there should be 10 meters between the rows. The area between trees should be kept free of weeds.

Trees are often spaced in a line one meter or less apart in order to create living fence posts. Trees are also planted to provide support for climbing crops such as pole beans, although only mature trees should be used for this purpose since the vine growth can choke off the young tree. Moringa trees can be planted in gardens; the tree’s root system does not compete with other crops for surface nutrients and the light shade provided by the tree will be beneficial to those vegetables which are less tolerant to direct sunlight. From the second year onwards, Moringa can be inter-cropped with maize, sunflower and other field crops. Sunflower is particularly recommended for helping to control weed growth] However, Moringa trees are reported to be highly competitive with sweet corn (Zea mays) and can reduce their yields by up to 50%.

Tree Pruning

As Moringa stenopetala tends to produce long branches that grow vertically and produce leaves and fruits only at their extremity, yields will be low if the trees are left to grow naturally. The tree can grow to heights of about 2 to 3 meters in the first year and continue to about 10-12 m thereafter. It is therefore essential to give the trees a good shape when they are young, by enhancing lateral branching thus creating bushy growth.
Germination by Seed

- Use poly bags with dimensions of about 18cm in height and 12cm in diameter.
- The soil mixture for the sacks should be light, i.e. 3 parts soil to 1 part sand.
- Plant two or three seeds in each sack, one to two centimeters deep.
- Keep moist but not too wet. Germination will occur within 10 to 15 days, depending on the age of the seed and pre-treatment method used.
- Remove extra seedlings, leaving one in each sack. Seedlings can be out-planted when they are 40-50cm high.

To encourage rapid germination, one of three pre-seeding treatments can be employed:

- Soak the seeds in water overnight before planting.
- Crack the shells before planting.
- Remove shells and plant kernels only.

Planting in the Field

If planting a large plot it is recommended to first plough the land. Prior to planting a seed or seedling, dig a planting pit about 50cm in depth and the same in width. This planting hole serves to loosen the soil and helps to retain moisture in the root zone, enabling the seedlings’ roots to develop rapidly. Compost or manure at the rate of 5kg per pit can be mixed with the fresh topsoil around the pit and used to fill the pit. Avoid using the soil taken out of the pit for this purpose: fresh topsoil contains beneficial microbes that can promote more effective root growth. The day before out planting, water the filled pits or wait until a good rain before out-planting seedlings. Fill in the hole before transplanting the seedling. In areas of heavy rainfall, the soil can be shaped in the form of a mound to encourage drainage. Do not water heavily for the first few days. If the seedlings fall over, tie them to sticks 40cm high for support.

Direct Sowing

If water is available for irrigation (i.e., in a backyard garden), trees can be seeded directly and grown anytime during the year. Prepare planting pit first, water, and then fill in the pit with topsoil mixed with compost or manure before planting seeds. In a large field, trees can be seeded directly at the beginning of the wet season.
rainfall, trees can be planted on small hills to encourage water run-off). Presence of a long taproot makes it resistant to periods of drought. Trees can be easily grown from seed or from cuttings. Moringa seeds have no dormancy period, so they can be planted as soon as they are mature and they will retain the ability to germinate for up to one year. Cold temperature inhibits seed germination of *M. stenopetala* under low temperature (at and below 15°C) an enforced dormancy has been found to occur. The speed of germination of untreated seed depend on temperature, humidity and watering. Seed placed at 6°C in cold room for 9 weeks showed 86% of germination. Also the viability will be remaining for several weeks evidenced by germination rate of 96-98% record for 44 months old seed (Moges, 2004).

Moringa trees will flower and fruit annually and in some regions twice annually. During its first year, a Moringa tree will grow up to three meters in height and produce flowers and fruit. Left alone, the tree can eventually reach 12 meters in height; however, the tree can be annually cut back to one meter from the ground. The tree will quickly recover and produce leaves and pods within easy reach.

3. Seed Processing and Production

Harvesting of brown colored moringa fruits at 20 days good quality seeds with high germination potential from the proximal and middle portion of the fruit compared to the distal portion. Black followed by brown colored seeds was superior with higher seedling quality attributes of germination and vigour index—than white seeds. Harvested pods must be dried for one or two days under shade with good ventilation. The seeds are extracted manually by opening the pods using gentle pressure on them. On opening, the seeds are separated freely. Small, shriveled and damaged seeds are removed.

Grading is carried out with the specific gravity separator. The optimum temperature range is 20-25°C. For seed testing, sowing seeds at a depth of 1cm in a sandy medium with 80 per cent moisture-retaining capacity represents the ideal conditions. Annual moringa seeds can be stored for up to 12 months, when freshly harvested seeds are dried to 8% moisture.
any other suggestion and recent molecular studies have pointed to a relationship with the cuniculaceae. These indicate that the taxonomic position of the family is no yet settled and is open for further studies.

Ecology

The wide natural distribution of *Moringa stenopetala* is already an indication of its ecological adaptability and it is important to define the climatic and edaphic requirement to growth and it is ecological optimum.

Climate

*M. stenopetala* is a fast-growing quite drought resistant that can grow in area with mean annual rainfall ranging from 500-1400 mm with long dry season for leaf production irrigation if mean annual rainfall less than 800 mm. Cold temperatures are limiting factor for the cultivation of the species because it does not tolerate frost (Moges, 2004) heavy frost may cause it to die-back to ground level. *Moringa* is a plant of marginal land and grows best in hot, semi arid tropics and sub tropics.

Altitude

* M. stenopetala* is found naturally in elevation between 1000 and 1800 m.a.s.l. the specie grow as high as 2000 m.a.s.l and as low as 300 m.a.s.l (Herbarium source).

Soil Requirement

The species require a well-drained loamy or sandy soil for optimal growth it does not grow on waterlogged or swampy best in dry sandy soil with soil PH ranges from slightly acidic to slightly alkaline (pH 5-9).

2. Cultivation of Moringa

*Moringa stenopetala* is believed to be native to horn Africa but is now found in different place in the tropics. It grows best in direct sunlight under 1000 meters altitude. It tolerates a wide range of soil conditions, but prefers well-drained sandy or loamy soil. Minimum annual rainfall requirements, but in waterlogged soil the roots have a tendency to rot. (In areas with heavy
It is already important crop in Ethiopia and being grown in Uganda, Sudan, and in Kenya. Among many uses of the species including as Agroforestry species (alley cropping), animal forage soil fertilizer, honey (flower nectar) green manure, medicine, water purification, animal fodder, and edible oil. One of the best known uses of Moringa stenopetala is the use of powder flocculate contaminants and to purify turbid water. The seed this species have flocculating and antimicrobial properties. Also, the seed are eaten as green roasted powder. This tree has in recent time been advocated as an outstanding indigenous source of highly digestible protein.

Some time we do not see gold which is present before our open eyes. There are many underutilized plants in Ethiopia which have the potential to bring lot of prosperity. "Moringa" an edible plant, is at the top of underutilized resources of Ethiopia. "Its tree could easily and cheaply be cultivated and grown in Ethiopia. Over 85% of Ethiopian peoples are depending in rain fed agriculture. Like many other African countries, water is a scarce commodity in Ethiopia and many of the farming practices are outdated. Using moringa as Agroforestry species can creates employment requires little financial investment and limited amount of water and organic manure. Moringa tree could easily and cheaply be cultivated and grown in the country without using chemicals. The poor countries such as Ethiopia should design and develop strategy to promote planting and use of Moringa on war footing in order to explore and utilize full benefits of this miracle tree.

Natural distribution

The origin Moringa stenopetala belongs to Northeast tropical Africa is a center of endemism plus diversity to the genus (Marks 1999, Edwards 2000) is also endemic to East Africa. Reported in Djibouti, Uganda and Sudan, the species is mainly present in northern Kenya and Ethiopia specially in Ethiopia in Gamu-Gofa, Keffa and Sidamo Borena and Debub omo Zone (Edwards et al, 2000).

Taxonomy

The family Moringaceae that is represented only a single gene Moringa. The genus Moringa is represented by 13 species to which Moringa stenopetala belongs. The taxonomic of position of the family is not clear. It has some features similar to those Brassicaceae and Capparidaceae but the seed structure does not agree with either of the above families. Pollen studies have not provide
1. Introduction

The genus Moringa is a small one represented by 13 species whose center of biodiversity is the Horn of Africa. The best-known species, *Moringa oleifera*, must have sprung from those East African “proto-roots” although it apparently completed its evolution across the Indian Ocean, in the foothills of the Himalayas. So although not African itself it derives directly from African stock. Eight of the species found here are endemic (occur nowhere else). Out of 13 Moringa species-only *M. oleifera* has been accorded research and development. The rest remain almost unknown to science. Perhaps they could provide even better food ingredients, flocculants, antibiotics, oils, or wood. Perhaps they have their own unique qualities. No one knows at present.

Of these ignored species, one stands out. Unequivocally African, Moringa stenopetala was domesticated in the East African lowlands. (Kenya and Ethiopia). Many different ecotypes and cultivars are still found in Ethiopia, for instance. The plant has been called cabbage tree and it is very similar to *Moringa oleifera* except that it is more drought tolerant and the leaves and seeds are larger. Some claim that its leaves are even tastier than moringa’s. In addition, this species is said to be even more promising as a coagulant for water clarification. For all that, though, it is barely known to anyone but the villagers whose ancient ancestors first put it to use.

A second species, *Moringa peregrina*, is another Horn-of-Africa native. It is used as a condiment and for several other purposes in West Africa but in modern times remains almost unstudied. Other Moringa species that found in horn Africa are Moringa arborea (northeastern Kenya), Moringa borziana (Kenya and Somalia) Moringa peregrina (Horn of Africa, Red Sea, Arabia), Moringa longituba (Kenya, Ethiopia, Somalia), Moringa rivae (Kenya and Ethiopia), Moringa ruppoliana (Kenya). The second widely cultivated species of Moringaceae family is *Moringa stenopetala* tree is found in many location of East Africa. It is slender, deciduous, perennial tree, to about a tree 6-10 m tall having a diameter of 60cm (DBH) thick at the base and a smooth bark with low timber quality but which for centuries has been traditional medicine its crown is strongly branched, sometimes with several trunks, and its wood is soft. The leaves are made up of leaflets (3.3-6.5cm) with a pointed rather than rounded tip; its seeds are ellipsoidal and not spherical, cream-colored rather than dark brown (Dechasa, 1995)
Environmental, Economical use of *Moringa stenopetala* and its Cultivation Practice

Girma Eshete

Ethiopian Institute of Agricultural Research, Forestry Research Center,

Email: girmeshee13@yahoo.com

ABSTRACT

*Moringa* (*Moringa stenopetala* (Baker.f.)) has gained much importance in the recent days due to its multiple uses and benefits to agriculture as an alternative to food supplies to treat malnutrition and also used as a metabolic conditioner to aid against endemic diseases in developing countries. Regarded as a miracle plant recently the roles of aqueous extracts of various parts in enhancing plant growth and productivity have been explored, making it even more valuable plant species. *Moringa* trees have been used to combat malnutrition, especially among infants and nursing mothers. Its natural plant growth hormones have the potential to create more sustainable and productive agricultural growth through reducing chemical additives on their farms. All parts of *Moringa* plant are used for food and medicinal and other purposes. The *Moringa* tree characterized by its minimal shade, deep rooted and does not compete with crops for soil nutrition and also it helps to improve organic matter in soil and improve soil fertility with this it is strongly recommended for Agro-forestry practices. Therefore, the role of *Moringa* in agro-forestry system should be understood and be given attention to enable this system to improve its productivity and remain sustainable.
Yalemntsehay Mekonnen. The multipurpose moringa tree: Ethiopia. Volume 10, examples of the development of pharmaceutical products from medicinal plants.


Sidduraju, P.; Becker, K. Antioxidant properties of various solvent extracts of total phenolic constituents from three different agro climatic origins of drumstick tree (*M. Oleifera* Lam.) Leaves. J. Agric. Food Chem. 2003, 51, 2144-2155


multipurpose trees Moringa Oleifera L. (horse radish tree) and Moringa Stenopetala L. J. Agric. Food Chem. 51, 3546-3553.


6. References


fresh leaves to make lead sauces. So Moringa leaves will be readily available to improve nutritional intake on a daily basis.

Having the above advantages we can recommend that:

- The other species of Moringa, Moringa Stenoptala, must be extensively studied for its nutritional and medicinal value.
- Training on processing of Moringa based products must be given for both home consumption and income generating purposes.
- Facilitate to upscale Moringa products to small medium scale industry
5. Conclusion and Recommendations

Acceptance of *M. Oleifera* as a nutritional supplement or a food additive in undernourished populations is compatible in those cultures that currently use green leafy plant sources in traditional dishes. Rural populations, and those populations who rely heavily on subsistence farming, may find using *M. Oleifera* leaves more compatible than purchasing non-locally produced food. Because households can produce their own *M. Oleifera* or find it in local markets, they are able to use it just as they would with other locally grown foods such as grains, legumes, root and/or tuber vegetables.

Conventional macro- and micronutrient supplements have well-proven efficacy, and *M. Oleifera* is likely not a suitable replacement for these nutrient dense supplements. However, it is a sustainable and economically sound nutrient-rich food option for populations who suffer from chronic or seasonal micro- and macronutrient deficiencies. The *M. Oleifera* tree costs little to plant -- in fact aid agencies who are working with *M. Oleifera* often donate seeds, and individuals can easily grow, maintain and utilize the tree provided they are not in high-density urban centers. Comparisons have been made with other nutrient-dense leafy vegetables in Niger (Sena *et al.*, 1998) and in Nigeria (Barminas *et al.*, 1998). No other plant, whose nutritional profile compares favorably with that of *M. Oleifera*, appears able to match its combination of overall utility, micro- and macronutrient composition, rapid growth habit, high yield leaf production, and survival in harsh climates. This strongly suggests that *M. Oleifera* is a unique pan-tropical dietary plant.

All parts of *Moringa Oleifera* is extremely a valuable source of nutrition and medicine for people of all ages. It is an exceptionally nutritious vegetable tree, with a variety of potential uses. It is known to have anti-inflammatory, anti-viral, antioxidant, anti-allergic and pain relief uses. It has also been put to use to fight a variety of infections. *Moringa* is also actively cultivated by the AVRDC in Taiwan. The AVRDC is the principal international centre for vegetable research and development in the world. Its mission is to reduce poverty and malnutrition in developing countries through improved production and consumption of vegetables. *Moringa* leaves can be dried and made into a powder by rubbing them over a sieve. This powder can be used in place of
* Plant parts will be designated by their first letters (in bold). – leaves (L), Flowers (F), seeds (S), Pods — drumsticks (P) Roots (R), Bark (B), Gum (G), Oil-from seeds (O)


At the same time according the researches done in Ethiopia from M. *Stenoptala* leaves were extracted biological active compounds (glycosides). The compounds were identified as rutin; 4-(4'-O-acetyl-L-rhamnosyloxy)-benzylisothiocyanate and 4-(4'-O-acetyl-L-rhamnosyloxy)-benzaldehyde (Alemayehu Mekonen, Tarekegn Gebreyesus, 2000). Two main compounds were identified from *M. stenopetala* seeds, glucoconringiin and O- (rhamnopyranosyloxy) benzyl glucosinolate, which were present at three per cent and 19 per cent of the dry mass of the seeds, respectively (Yalemstehay Mekonnen).
<table>
<thead>
<tr>
<th>Condition</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes / hypoglycemia</td>
<td>LP</td>
</tr>
<tr>
<td>Diuretic</td>
<td>LFRG</td>
</tr>
<tr>
<td>Tonic</td>
<td>F</td>
</tr>
<tr>
<td>DETOXIFICATION</td>
<td></td>
</tr>
<tr>
<td>Purgative</td>
<td>O</td>
</tr>
<tr>
<td>Snakebite</td>
<td>B</td>
</tr>
<tr>
<td>Scorpion – bite</td>
<td>B</td>
</tr>
<tr>
<td>DIGESTIVE DISORDERS</td>
<td></td>
</tr>
<tr>
<td>Diarrhea</td>
<td>I.R</td>
</tr>
<tr>
<td>Dysentery</td>
<td>LG</td>
</tr>
<tr>
<td>Ulcer/Gastritis</td>
<td>LS</td>
</tr>
<tr>
<td>INFLAMMATION</td>
<td></td>
</tr>
<tr>
<td>Rheumatism</td>
<td>LFSPRG</td>
</tr>
<tr>
<td>Joint pain</td>
<td>P</td>
</tr>
<tr>
<td>Edema</td>
<td>R</td>
</tr>
<tr>
<td>NUTRITIONAL</td>
<td></td>
</tr>
<tr>
<td>Antioxidant</td>
<td>LO</td>
</tr>
<tr>
<td>Energy</td>
<td>LSO</td>
</tr>
<tr>
<td>Protein</td>
<td>LS</td>
</tr>
<tr>
<td>Vitamin/mineral deficiency</td>
<td>LS</td>
</tr>
<tr>
<td>REPRODUCTIVE HEALTH</td>
<td></td>
</tr>
<tr>
<td>Birth control</td>
<td>B</td>
</tr>
<tr>
<td>Lactation Enhancer</td>
<td>L</td>
</tr>
<tr>
<td>Aphrodisiac</td>
<td>RB</td>
</tr>
<tr>
<td>GENERAL DISORDERS/CONDITIONS</td>
<td></td>
</tr>
<tr>
<td>Bladder</td>
<td>OS</td>
</tr>
<tr>
<td>Catarah</td>
<td>LF</td>
</tr>
<tr>
<td>Scurvy</td>
<td>LSRBO</td>
</tr>
<tr>
<td>Spleenomegaly</td>
<td>R</td>
</tr>
</tbody>
</table>
The table below shows a reported nutritional, therapeutic and prophylactic uses of *Moringa Oleifera*.

<table>
<thead>
<tr>
<th>Traditional use (condition) effect</th>
<th>Plant part*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimicrobial / Biocidal</td>
<td>LFSPRBGO</td>
</tr>
<tr>
<td><strong>BACTERIAL</strong></td>
<td></td>
</tr>
<tr>
<td>Dental cares / Toothache</td>
<td>RBG</td>
</tr>
<tr>
<td>Syphilis / Typhoid</td>
<td>G</td>
</tr>
<tr>
<td>Urinary Tract infection</td>
<td>L</td>
</tr>
<tr>
<td><strong>VIRAL</strong></td>
<td></td>
</tr>
<tr>
<td>Common cold</td>
<td>FRB</td>
</tr>
<tr>
<td>Herpes simplex virus (HSV - 1)</td>
<td>L</td>
</tr>
<tr>
<td>HIV – AIDS</td>
<td>L</td>
</tr>
<tr>
<td><strong>PARASITES</strong></td>
<td></td>
</tr>
<tr>
<td>Helminthes</td>
<td>LFP</td>
</tr>
<tr>
<td>Schistosomes</td>
<td>S</td>
</tr>
<tr>
<td>Trypanosomes</td>
<td>LR</td>
</tr>
<tr>
<td><strong>NOT ATTRIBUTED TO A SPECIFIC PATHOGEN</strong></td>
<td></td>
</tr>
<tr>
<td>Bronchitis</td>
<td>L</td>
</tr>
<tr>
<td>Earache</td>
<td>G</td>
</tr>
<tr>
<td>Fever</td>
<td>LRGS</td>
</tr>
<tr>
<td>Skin (Darmal)</td>
<td>O,S</td>
</tr>
<tr>
<td>Throat infection</td>
<td>F</td>
</tr>
<tr>
<td><strong>ASTHMA</strong></td>
<td></td>
</tr>
<tr>
<td><strong>CANCER THERAPY/PROTECTION</strong></td>
<td></td>
</tr>
<tr>
<td>Anti-tumor</td>
<td>LFSB</td>
</tr>
<tr>
<td>Prostate</td>
<td>L</td>
</tr>
<tr>
<td><strong>CIRCULATORY / ENDOCRINE DISORDERS</strong></td>
<td></td>
</tr>
<tr>
<td>Anti – anemic</td>
<td>L</td>
</tr>
<tr>
<td>Anti – hypertensive</td>
<td>LP</td>
</tr>
</tbody>
</table>
immune system, which usually becomes compromised in those suffering from type I and type II diabetes. The combination of Moringa Oleifera and Irvingia gabonensis will be very effective in the management of diabetes. Omoruyi and Adamson (1994) and Judith, et al. (2005) noted that Irvingia gabonensis could be used wholly or as supplement in the treatment of type II diabetics and in reducing obesity. The plant is known to possess many key anti-inflammatory benefits, and anti-inflammatory supplements for management of blood sugar and diabetes symptoms in people, since it does not have negative side effects.

Moringa Oleifera and Some Related Sickness Moringa tree is a good source of calcium and phosphorus. Due to these reasons, it is used in Siddha medicines, as sexual virility drug for treating erectile dysfunction in men and in women, for prolong sexual activity. The tree’s bark, roots, fruits, flowers, leaves, seeds and gum are also used as antiseptic and in treating rheumatism, venomous bites and other conditions (Wikipedia, 2010). Moringa Oleifera was proven to have anti-inflammatory properties in 2008 by the Faculty of Medicine/ Health Sciences of the Putra University in Malaysia. The plant possesses both antinociceptive and anti-inflammatory properties that have suppressing effects on “cox-2 enzyme”. This enzyme is responsible for inflammation processes and pain (the Moringa/medicinal-uses/anti-inflammatory, 2010). The potential of Moringa Oleifera was affirmed useful in the treatment and management of “gout and arthritis”. The impact of HIV/AIDS are many and intertwined (Villarreal and Anyonge, 2006). The authors noted that the impacts can be felt most dramatically in the reduction of labor force, impoverishment and the loss of knowledge that is transferred from one generation to another. But today, Moringa has come to the rescue to balance the diet. Burger and Herzing (2002), observed that 70% of all HIV positive people live in Sub-Sahara Africa where malnutrition is rife.

The authors also noted that, Moringa powder is an immune stimulant for HIV positive people, particularly for those who cannot afford good nutrition and medicine in Africa. It is known that certain elements and vitamins in Moringa Oleifera can stimulate the immune system and thereby improve the health and lifestyle of an individual for many years. Recently, it has been promoted by non-governmental organization (NGOs) and faith-based organizations (FBOs) to meet the nutritional needs of communities affected by HIV/AIDS (Villarreal and Anyaonge, 2006).
titer (see the table below). In many cultures throughout the tropics, differentiation between food and medicinal uses of plants (e.g. bark, fruit, leaves, nuts, seeds, tubers, roots and flowers) is very difficult, because plant uses span both categories; and this is deeply ingrained in the traditions and fabric of the community (Lockett et al., 2000).

On the other hand Mice treated with 900 mg/kg of *M. Stenopetala* extract per kg of body weight showed a significant increase in body weight compared to the controls. Neither a significant change in the weight nor in histopathology of liver and kidney were observed in the animals treated with aqueous extract of *M. Stenopetala* compared to those of the controls. Serum glucose level and serum cholesterol level decreased significantly after six weeks treatment (Desta Ghebreselassie et al., 2011).

*Moringa Oleifera* and Cancer: *Moringa Oleifera* is a plant with many medicinal properties known globally. These natural resources are helpful in a comprehensive treatment of cancer. Research revealed that, it has anti-tumor capacity. It contains vitamins, minerals and amino acids which are critical for good health. The leaves and stems of *Moringa Oleifera* are known to have large amounts of their calcium bound in calcium oxalate crystals (Olson and Carlquist, 2001).

*Moringa Oleifera* and Diabetes: Since World War II, diabetes has been advancing relentlessly in developed countries, where it is now one of the leading causes of death (Luchington, et al., 2005). He opined that in America, a new diabetic is discovered every 50 seconds. This disorder is caused by a deficiency in insulin production (Ramalingam, 2010). This disease is prevalent in the society, irrespective of race.

Diabetes is of two kinds, namely: type I – which afflicts 5 percent of diabetics; they are usually thin and rarely overweight. Type I diabetes is common among people within the age of 20 years, although it can happen at any age. It normally begins at childhood and is commonly known as juvenile diabetes. Sufferers cannot survive without insulin. it is now officially called insulin-dependent diabetes mellitus (IDDM). Type II, otherwise called adult onset diabetes or noninsulin – dependent diabetes mellitus (NIDDM), is common among people between ages of 40 – 50 years and affects more than 90 percent of diabetics (Ludington, 2005). It is no longer news that diabetes has no cure, rather it can be managed. The side effects of orthodox medicine most often, complicate issues; hence *Moringa Oleifera* which is health friendly is advocated by many scholars for effective management of diabetes. *Moringa Oleifera* is known to naturally boost the

A number of natural compounds have been isolated from M. Oleifera leaves including fully acetylated glycosides bearing thiocarbamates, carbamates or nitriles (Faizi et al, 1995; Murakami et al, 1998). Glycosides containing isothiocyanates, malonates and flavonoids have also been identified and isolated in the leaves of the Moringa plant (Faizi et al, 1994; Bennett et al, 2003; Miean et al, 2001). In particular, quercetin and kaempferol glycosides are broken down to yield the natural antioxidant flavonoids, quercetin and kaempferol, indicating these glycosides can be efficiently hydrolyzed to their respective aglycones (Miean et al, 2001; Bennett et al, 2003; Wu et al, 2003). Many plant glycosides can be used as treatments for cancer or chronic conditions such as high cholesterol and atherosclerosis (Chumark et al, 2008; Ghasi et al, 2000; Murakami et al, 1998). Flavonoids exist widely in the plant kingdom and are especially common in leaves, flowering tissues and pollens. Plant flavonoids are important to the diet because of their effects on human nutrition. These phytochemicals can modulate lipid peroxidation involved in atherogenesis, carcinogenesis and thrombosis and other known properties of free radical scavenging or inhibition of hydrolytic and oxidative enzymes (phospholipidase A2, cyclooxygenase, lipoxygenase) shows strong antioxidant and anti-inflammatory activity (Siddhuraju et al, 2003). Numerous studies have indicated that flavonoids also have anti-carcinogenic, anti-viral and anti-estrogenic activities (Havsteen, 2002; Miean et al, 2001; Middleton et al., 2000). A high intake of flavonoids has been linked with a reduced risk of cardiovascular disease, osteoporosis and other age-related degenerative diseases (Havsteen, 2002; Middleton et al., 2000; Morris et al., 2006). For example, much of the interest has recently been focused on using flavonoids anticancerous properties (Faizi et al, 1998; Guevara et al, 1999; Miean et al, 2001) as well as using quercetin and kaempferol to fight osteoporosis (Prouilhetea el al, 2004). These identified bioactive compounds in the leaves of M. Oleifera make this an excellent candidate for nutritional and pharmaceutical supplementation.

Moringa preparations have been cited in scientific literatures, as having antibiotic, antitrypanosomal, and hypotensive, antispasmodic, antiulcer, anti-inflammatory, hypcholeseterolemic and hypoglycemic activities as well as having considerable efficacy in water purification by flocculation, sedimentation, antibiosis and even reduction of schistosome cercarie
Vitamin E-tocopherol acetate (mg) | - | - | 113
---|---|---|---
Arginine (mg) | 90 | 402 | 1,325
Histidine (mg) | 27.5 | 141 | 613
Lysine (mg) | 37.5 | 288 | 1,325
Tryptophan (mg) | 20 | 127 | 425

Source: Ozumba (2008)

4. Medicinal value

People in many countries have used *Moringa* leaves as traditional medicine for common ailments. The bark, sap, roots, leaves, seeds, oil and flowers are used in traditional medicine in several countries. In Jamaica, the sap is used for a blue dye. In Malaysia and Puerto Rico, *Moringa* is traditionally used for intestinal worms. In Guatemala, it is used for skin infections and sores, while in the Philippines, it is used for the treatment of anemia, glandular swelling and lactating problems. In siddha medicines, these drumstick seeds are used as a sexual virility drug for treating erectile dysfunction in men and also in women, for prolonged sexual activity.

Epidemiological studies have demonstrated that vegetables and fruits rich in carotenoids are related to a lower risk of cancer, cardiovascular disease, age-related macular degeneration and the formation of cataracts (Lakshminarayan et al, 2005; Bowman et al, 1995; Krichevsky et al. 1999). Identification of these vitamins would be a great advantage to the nutritional attributes of the *Moringa* leaves. In addition to the provitamins, *Moringa* leaves are also considered a rich source of minerals (Gupta et al, 1989), polyphenols (Bennett et al, 2003), flavonoids (Lako et al, 2007; Siddharaju et al, 2003), alkaloids, and proteins (Solvia et al, 2005; Sarwatt et al, 2002). These essential nutrients can help decrease the nutritional deficit and combat many chronic inflammatory diseases.

According to Hartwell (1967-1971), the leaves were used in traditional remedies for tumors (Faizi et al, 1998; Guevara et al, 1999) and extensively used as a natural sleep aid, applied as a poultice to sores, rubbed on temples for headaches, and as a purgative cleanser (Fuglie, 1999; Fahey, 2005). These applications address the use of *M. Oleifera* leaves in the food industry, as a synergistic natural product applied to ethnic foods, and the medical industry, as a preventative
Leaf nutrient composition will vary depending on the geographic region the leaves are sampled from and the type of analysis used. This table acts to give a general idea of the nutrient content of the leaves.

**Represents Adequate Intake (AI) for an individual**

Table 3. Laboratory analysis of the mineral, amino acid and other contents of *Moringa* pods, fresh leaves and powder.

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Pods</th>
<th>Fresh leaves</th>
<th>Dried leaves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>86.9</td>
<td>75</td>
<td>7.5</td>
</tr>
<tr>
<td>Calories</td>
<td>26</td>
<td>92</td>
<td>205</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>2.5</td>
<td>6.7</td>
<td>27.1</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>0.1</td>
<td>1.7</td>
<td>2.3</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>3.7</td>
<td>13.4</td>
<td>38.2</td>
</tr>
<tr>
<td>Fiber (g)</td>
<td>48</td>
<td>0.9</td>
<td>19.2</td>
</tr>
<tr>
<td>Minerals (g)</td>
<td>2</td>
<td>2.3</td>
<td>-</td>
</tr>
<tr>
<td>Calcium, Ca. (mg)</td>
<td>30</td>
<td>440</td>
<td>2,003</td>
</tr>
<tr>
<td>Magnesium, Mg. (mg)</td>
<td>24</td>
<td>24</td>
<td>368</td>
</tr>
<tr>
<td>Phosphorus, P. (mg)</td>
<td>110</td>
<td>70</td>
<td>204</td>
</tr>
<tr>
<td>Potassium, K. (mg)</td>
<td>259</td>
<td>259</td>
<td>1,324</td>
</tr>
<tr>
<td>Copper, Cu. (mg)</td>
<td>3.1</td>
<td>1.1</td>
<td>0.57</td>
</tr>
<tr>
<td>Zinc, Zn. (mg)</td>
<td>-</td>
<td>-</td>
<td>3.29</td>
</tr>
<tr>
<td>Iron, Fe. (mg)</td>
<td>53</td>
<td>7</td>
<td>28.2</td>
</tr>
<tr>
<td>Sulphur, S. (mg)</td>
<td>137</td>
<td>137</td>
<td>870</td>
</tr>
<tr>
<td>Selenium, Se. (mg)</td>
<td>-</td>
<td>-</td>
<td>0.09</td>
</tr>
<tr>
<td>Oxalic acid (mg)</td>
<td>10</td>
<td>101</td>
<td>1,600</td>
</tr>
<tr>
<td>Vitamin A-B carotene (mg)</td>
<td>0.11</td>
<td>6.8</td>
<td>18.9</td>
</tr>
<tr>
<td>Vitamin B-choline (mg)</td>
<td>423</td>
<td>423</td>
<td>-</td>
</tr>
<tr>
<td>Vitamin B1-thiamin (mg)</td>
<td>0.05</td>
<td>0.21</td>
<td>2.64</td>
</tr>
<tr>
<td>Vitamin B2-riboflavin (mg)</td>
<td>0.07</td>
<td>0.05</td>
<td>20.5</td>
</tr>
<tr>
<td>Vitamin B3-nicotinic acid (mg)</td>
<td>0.2</td>
<td>0.8</td>
<td>8.2</td>
</tr>
<tr>
<td>Vitamin C-ascorbic acid (mg)</td>
<td>120</td>
<td>220</td>
<td>17.3</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------------</td>
<td>---------------</td>
<td>------------</td>
</tr>
<tr>
<td>Magnesium</td>
<td>42 mg</td>
<td>88.32 mg</td>
<td>80-130 mg/day</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>70 mg</td>
<td>48.96 mg</td>
<td>460-500 mg/day</td>
</tr>
<tr>
<td>Potassium</td>
<td>.26 g</td>
<td>0.32 g</td>
<td>3.0-3.8 g/day**</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.16 mg</td>
<td>.79 mg</td>
<td>3-5 mg/day</td>
</tr>
<tr>
<td>Essential Amino Acids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Histidine</td>
<td>149.8 mg</td>
<td>147.12 mg</td>
<td>8 mg/g protein</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>299.6 mg</td>
<td>198 mg</td>
<td>25 mg/g protein</td>
</tr>
<tr>
<td>Leucine</td>
<td>492.2 mg</td>
<td>468 mg</td>
<td>55 mg/g protein</td>
</tr>
<tr>
<td>Lysine</td>
<td>342.4 mg</td>
<td>318 mg</td>
<td>51 mg/g protein</td>
</tr>
<tr>
<td>Methionine + Cysteine</td>
<td>117.7 mg</td>
<td>84 mg</td>
<td>25 mg/g protein</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>310.3 mg</td>
<td>333.12 mg</td>
<td>47 mg/g protein</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>117.7 mg</td>
<td>285.12 mg</td>
<td>27 mg/g protein</td>
</tr>
<tr>
<td>Threonine</td>
<td>107 mg</td>
<td>102 mg</td>
<td>7 mg/g protein</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>374.5 mg</td>
<td>255.12 mg</td>
<td>32 mg/g protein</td>
</tr>
<tr>
<td>Valine</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*aTrees for Life (2005) reported *M. Oleifera* fresh leaf content from Gopalan et al. (1971).
*cRecommended Daily Allowance (RDA) values are given as an estimate of what an individual’s recommended intake should be. For the purpose of this paper, these values should be interpreted as a general comparison of leaf content to what an average healthy child should intake. Source: Food and Nutrition Board, Institute of Medicine, National Academy of Sciences Dietary Reference Intake database (2002)
*dGopalan et al. (1971) originally expressed amino acid content per g N, and have been converted to mg per 100g leaves*
(Seshadri & Nambiar, 2003). In populations where traditional medicine is practiced and preferred, *M. Oleifera* may likely be accepted as a way of treating under-nutrition.


<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Fresh leaves (value/100g edible portion)(^a)</th>
<th>Dried leaves (value/24g=3tbsp edible portion)(^b)</th>
<th>RDA for healthy children age 1-8 years old (^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calories</strong></td>
<td>92 cal</td>
<td>49 cal</td>
<td></td>
</tr>
<tr>
<td><strong>Macronutrients</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>6.70 g</td>
<td>6.5 g</td>
<td>13-19g/day</td>
</tr>
<tr>
<td>Fat</td>
<td>1.70 g</td>
<td>0.55 g</td>
<td>30-40 g/day</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>12.5 g</td>
<td>9.2 g</td>
<td>130 g/day</td>
</tr>
<tr>
<td><strong>Micronutrients</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carotene (Vitamin A)</td>
<td>6.78 mg</td>
<td>4.54 mg</td>
<td>300-400 (\mu g/\text{day})</td>
</tr>
<tr>
<td>Thiamin (B1)</td>
<td>0.06 mg</td>
<td>0.63 mg</td>
<td>.5-.6 (\text{mg/ day})</td>
</tr>
<tr>
<td>Riboflavin (B2)</td>
<td>0.05 mg</td>
<td>4.92 mg</td>
<td>.5-.6 (\text{mg/ day})</td>
</tr>
<tr>
<td>Niacin (B3)</td>
<td>0.8 mg</td>
<td>1.97 mg</td>
<td>6-8 (\text{mg/day})</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>220 mg</td>
<td>4.15 mg</td>
<td>15-25 (\text{mg/day})</td>
</tr>
<tr>
<td>Calcium</td>
<td>440 mg</td>
<td>480.72 mg</td>
<td>500-800 (\text{mg/day})**</td>
</tr>
<tr>
<td>Copper</td>
<td>0.07 mg</td>
<td>0.14 mg</td>
<td>340-440 (\text{mg/day})</td>
</tr>
<tr>
<td>Fiber</td>
<td>0.90 g</td>
<td>4.61 g</td>
<td>19-25 (\text{g/day})**</td>
</tr>
<tr>
<td>Iron</td>
<td>0.85 mg</td>
<td>6.77 mg</td>
<td>7-10 (\text{mg/day})</td>
</tr>
</tbody>
</table>
of Moringa are now so well known that there seems to be little doubt of the substantial health benefit to be realized by consumption of Moringa leaf powder in situations where starvation is imminent. Nutritional analysis indicates that Moringa leaves contain a wealth of essential, disease preventing nutrients. They even contain all of the essential amino acids, which is unusual for a plant source. Since the dried leaves are concentrated, they contain higher amounts of many of these nutrients, except vitamin C. (Dolcas et al., 2008). Vitamin A is obtained from vegetables in the form of its precursor, carotene. The intestine only absorbs a fraction of the carotene in foods. Thus, there are differing views on how to calculate the amount of carotene that is absorbed and converted to vitamin A. Thus the chart below gives the figures for carotene or beta-carotene. The most commonly accepted conversion factor of carotene to vitamin A (retinol) is 6:1

Traditional dishes around the world include green leafy plant sources which can be substituted or augmented with M. Oleifera leaves. An Indian study evaluated food attitudes in children and infants, where they were given 30 g and 15 g respectively of M. Oleifera leaves mixed with 10 g of legumes and the dish was found to be coarse and bitter (Gopaldas et al., 1973). In Malawi, 63% of households preferred M. Oleifera leaves over commonly used pumpkin leaves (Babu, 2000). Nambiar et al. (2003) evaluated the feasibility and acceptability of M. Oleifera leaf powder used in preschool meals prepared by staff at the Indian Integrated Child Development Scheme (ICDS). Forty children aged 1-5 years were given 5-7g dried leaf powder added to their daily salty snack. Acceptability (gauged by facial expression, demand for food, and measurement of food left at the end of the meal), was no different than the acceptability of diet to a control group (n=20) receiving the regular recipe (Nambiar et al., 2003). A similar acceptability trial utilized a panel of 12 women age 18-21 years old given traditional Indian recipes with 6-25g freshly blanched M. Oleifera leaves (Nambiar & Parnami, 2008). Pulse recipes that included 20 g of leaves, calculated to give the women 82.5% to 83.3% of their RDA for vitamin A, were the most acceptable. Other studies have demonstrated that peoples' taste perceptions of M. Oleifera leaves varies from “tasteless” to “slightly bitter” depending on the geographic region from which the leaves come. Children given M. Oleifera leaves in a variety of traditional Indian recipes revealed no specific like or dislike although mothers reported that children preferred having the leaves incorporated into the cereal-pulse dough which is used in several traditional dishes.
Oleifera leaves in India was found to be highly bioavailable in an in vitro model (Pullakhandam & Failla, 2007). Using a rat model, the comparative bioavailability of β-carotene in fresh and dried M. Oleifera leaves was evaluated by Nambiar & Seshadri (2001). Rats receiving M. Oleifera leaves increased their food intake and weight gain compared to rats given either synthetic vitamin A or vitamin A adequate diets. Though synthetic vitamin A fed rats had the highest serum and liver vitamin A levels, the M. Oleifera fed rats had significantly higher serum and liver vitamin A levels than at baseline.

The bioavailability of thiamine, riboflavin and niacin from dried M. Oleifera leaves was evaluated in six 17-20 year old subjects in India. Subjects were given a series of experimental curry-based diets with leaves of trees noted for their contents of thiamine, riboflavin, and niacin (Girija et al., 1982). Diets containing M. Oleifera leaves resulted in urinary excretion of 11.72 % of thiamine, 10.78 % of riboflavin, and 9.44 % of niacin intake, leading the authors to conclude that this equated to bioavailability.

Dried M. Oleifera leaves are high in calcium but also contain substantial quantities of oxalic acid, which interferes with the absorption of calcium. Rats were fed calcium-rich diets containing: (a) 15 g dried M. Oleifera leaf powder, (b) 30 g milk powder, or (c) 4 g dried kilkeerai (Amaranthus tricolor) leaf powder per 100 g of basal diet. The calcium contents of the M. Oleifera leaf diet and the milk diet were the same (ca. 635 mg per 100 g of diet), but the M. Oleifera leaves had 160 mg oxalates per 100 g diet. Although milk did provide for the best absorption and retention of calcium, 73% of the calcium provided by M. Oleifera was absorbed and 59% was retained, thus providing a good alternative or ancillary source of calcium when milk is not available (Pankaja & Prakash, 1994).

Moringa also helps to purity water, a cheaper alternative to mechanical filtration. The immature pods called drumsticks, are probably the most valued and widely used part of the tree. They are commonly consumed in India and are generally prepared in a similar fashion to green beans and have a slight asparagus taste. The seeds are sometimes removed from more mature pods and eaten like peas or roasted like nuts. The flowers are edible when cooked, and are said to taste like mushrooms. In West Africa and Senegal, there are reports of countries’ instances of life-saving nutritional rescue that are attributed to Moringa (Fuglie, 1999). In fact, the nutritional properties
Nutrition experts recommend that proteins (or amino acids) should account 10-15% of the calories in a balanced diet, although requirements for protein are affected by age, health, weight, and other factors. Generally, a normal adult requires approximately 0.36 grams of protein per pound of body weight, or 0.8 grams of good quality protein per kg weight. That makes a total of 50-80 grams daily. Proteins are made up of amino acids. There are twenty amino acids present in the human body. Of those nine are known to be essential and have to be supplied from diet since the human body cannot synthesize them, as it does with the other 11 amino acids. Few foods are known to contain all essential amino acids. The nine essential amino acids are: histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. Histidine is considered essential for children and babies, not for adults.

In developing tropical countries, Moringa trees have been used to combat malnutrition, especially among infants and nursing mothers. The young leaves can be eaten fresh, cooked or stored as dried powder for many months without refrigeration, and without loss of nutritional value. The plant is a promising food source in the tropics because the tree retains full green leaves at the end of the dry season when other food sources are typically scarce. According to Optima of Africa Ltd (a company involved in harnessing the tree in Tanzania), twenty five grams daily of Moringa leaf powder will give a child the following recommended daily diets; protein 42%, calcium 125%, magnesium 61%, potassium 41%, iron 71%, vitamin A 272%, and vitamin C 22% (Donovan, 2007). These percentages are considered outstanding, being available even when other food sources are scarce.

It is commonly said that Moringa leaves contain four times vitamin A than carrots, four times calcium than milk, three times more iron than spinach, seven times vitamin C than oranges and three times potassium than bananas and that the protein quality of Moringa leaves competitors that of milk and eggs. Leaves and pods of Moringa Oleifera can be an extremely valuable source of nutrition for people of all ages (Table 2 and 3). While the reported nutrient content of M. Oleifera leaves, both fresh, and in powdered form, appears promising in terms of a nutritional supplement, an understanding of the bioavailability of these nutrients is limited to vitamins A and B and calcium. M. Oleifera is one of the richest natural sources of β-carotene or provitamin A (Kumar, 2004), thus prompting much research interest in India. β-carotene and lutein from M.
2.2.2. Washing

Wash leaflets in troughs using clean potable water to remove dirt. Wash leaves again in 1% saline solution for 3-5 minutes to remove microbes. Finally wash again in clean water. Leaves are now ready for drying. Drain each trough after each wash: fresh leaves must always be washed with fresh water.

2.2.3. Draining

Strain water from the leaves in buckets that have been perforated, spread leaflets on trays made with food-grade mesh and leave to drain for 15 minutes before taking them to the dryer.

2.2.4. Drying

There are three main methods for drying *Moringa* leaves.

**Room drying**

Spread the leaflets thinly on mesh tied on racks (mosquito net mesh can be used) in a well-ventilated room. This room should be insect, rodent and dust proof. Air circulation can be improved by using ceiling and floor level vents protected with a clean filter to keep the sun and dust out. It is possible to use a fan, but the air must not be directly oriented towards the leaves, as it can increase contamination with germs in the air. It is advisable to turn the leaves over at least once, with sterile gloves, to improve uniform drying. Leaves should be completely dry within a maximum of 4 days. The loading density should not exceed 1 kg/m². However, room-dried leaves cannot be guaranteed mold-free with the maximum recommended moisture content of 10%. Therefore, we do not advise this method.

**Solar drying**

The polyethylene for use should be UV treated or opaque (if the plastic is black, beware of temperature increases and be sure it does not go above 55°C). The air intake should be filtered to keep out dust. Organza or muslin cloth can be used as a filter. Spread the leaves thinly on mesh and dry in the dryer for about 4 hours (Temperature range is 35°C-55°C on a very sunny day). The final product should be very brittle. Solar drying can be used for both small and large scale processing, particularly for those in rural communities and plenty of sunshine. Loading density should not exceed 2 kg/m².
2.1. Harvesting of seeds

In seed farms, pods should be harvested as early as possible when they reach maturity, i.e. when they turn brown and dry. Fruits should open easily. Seeds are extracted, bagged, and stored in a dry place. *Moringa* branches break easily; it is not recommended to climb up the tree to harvest the fruits.

2.1.1. Transportation

Transportation in *Moringa* leaf production is a very critical step in ensuring high quality leaves for consumption. There are two options, either strip the leaves off the branches before transporting them to the processing center or cut big branches and transport whole to the processing center if nearby, before defoliating (stripping or removing the leaves from the branch). TRAN
Leaves can be tied together in bunches by their stem or better, thinly spread out on trays or mesh to reduce temperature build up. Freshly harvested material should be transported to the processing center as quickly as possible to avoid deterioration.
Fresh *Moringa* leaves, transported loosely, should be well ventilated. For shorter distances aerated baskets or perforated plastic containers should be used to transport the fresh leaves. Avoid open vehicles. Under no circumstances should people or goods be placed on top of leaves. Transportation should be during the cooler parts of the day: early morning, evening or night. Leaves being transported over long distances should be in air-conditioned or refrigerated vans to keep them cool until delivery at the processing center.

2.2. Processing of *Moringa* leaves

Processing should start immediately after harvesting and transporting the leaves to the processing point.

2.2.1. Stripping the leaflets

Strip all the leaflets from the leaf petiole. This can be done directly from the branches if the leaves have not been stripped off the main branch before transportation. At this stage, diseased and damaged leaves are discarded.
used oils such as palm, canola and soybean oil when comparing fatty acid composition (Table 1). Oils with high amounts of monounsaturated (oleic type) fatty acids are desirable due to an association with decreased risk of coronary heart disease (Mensink et al, 1990; Aldulkarim et al, 2007).

The whole seeds can also be eaten green, roasted or powdered, and steamed in tea and curries (Fahey, 2005). The pods and seeds, often referred to as *Moringa* kernels, have a taste that ranges from sweet to bitter and are most popularly consumed after frying to get a peanut-like taste (Makkar et al, 1996).

Table 1. Fatty acid composition of oils in a frying test (Abdulkarim et al, 2007)

<table>
<thead>
<tr>
<th>Oils</th>
<th>Palmitic Acid</th>
<th>Oleic Acid</th>
<th>Linoleic Acid</th>
<th>Monosaturated fatty acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palm olein</td>
<td>37.7</td>
<td>45.6</td>
<td>10.8</td>
<td>46.3</td>
</tr>
<tr>
<td>Soybean</td>
<td>8.9</td>
<td>57.4</td>
<td>22.8</td>
<td>58.6</td>
</tr>
<tr>
<td>Canola</td>
<td>11.3</td>
<td>24.8</td>
<td>53.5</td>
<td>25.1</td>
</tr>
<tr>
<td><em>Moringa</em> Oleifera</td>
<td>6.1</td>
<td>74.5</td>
<td>0.7</td>
<td>78.1</td>
</tr>
</tbody>
</table>

The results are expressed as a percentage/DW

2. Harvesting and processing of *Moringa* leaves

The *Moringa* tree has a compound leaf: one leaf is made up of multiple leaflets. What is referred to here as a leaf is precisely multiple leaflets attached to the rachis which stems from the branch. Manual harvesting of shoots and leaves with a pair of shears, a sickle or a sharp knife is recommended. All shoots should be cut at the desired height, i.e. 30 cm to 1 m above ground. Harvesting can also be done by removing the leaves, picking them directly off the tree.

A high level of hygiene should be maintained. Produce should be harvested at the coolest time of the day: early morning or late in the evening. It is important to make sure there is no dew on the produce before harvesting, especially in the morning, to avoid rot during transport.
fine machine lubrication, and in the manufacture of perfume and hair care products (Adebayo et al., 2011).

*Moringa* tree contains many nutrients such as essential vitamins, essential minerals, amino acids, beta-carotene, anti-oxidants, anti-inflammatory nutrients, phytochemicals and it also contains both omega-3 and omega-6 fatty acids. The leaves are highly nutritious, being a significant source of beta-carotene, Vitamin C, protein, iron, and potassium suitable for utilization in many of developing countries where malnutrition is a major concern (Bennett et al., 2003; Aslam et al., 2005; Amaglo et al., 2010; Gowrishankar et al., 2010). The leaves are cooked and used like spinach. In addition to being used fresh as a substitute for greens, its leaves are commonly dried and crushed into a powder, and used in soups and sauces. The tree is a good source for calcium and phosphorus. In the West, one of the best known uses for *Moringa* is the use of powdered seeds to flocculate contaminants and purify drinking water (Berger et al., 1984; Gassenschmidt et al., 1995), but the seeds are also eaten green, roasted, powdered and steeped for tea or used in curries (50).

The publication by Ozumba (2008) outlined several medicinal uses of *Moringa Oleifera* indicating that up to 81 remedies are produced from several parts of the tree. For example, 22 remedies are produced from the leaves, 8 from the flowers, 3 from the pods, 14 from the roots, 17 from the root bark and stem bark, 9 from the gum, 4 from the seed and 4 from the seed oil. Traditionally, the leaves when pulverized are rubbed on the forehead to relieve migraine headache. *Moringa* is regarded as “Dr. Cure all” as suggested by Ramunze (2003).

The seeds contain much of the plant’s edible oil which is used as a cooking oil for frying and as a salad oil for dressing. The fatty acid compositions of solvent and enzyme-extracted oil from *M. Oleifera* seeds showed 67.9% oleic acid in the solvent extract and 70.0% in the enzyme extracts. Other prominent fatty acids in *Moringa* oil include palmitic (7.8% and 6.8%), stearic (7.6% and 6.5%), and behenic (6.2% and 5.8%) acids for the solvent and enzyme-extracted oils, respectively (Abdulkarim et al, 2005).

Due to the high monounsaturated to saturated fatty acid ratio, *Moringa* seed oil could be considered an acceptable substitute for highly monounsaturated oils such as olive oil (Tsaknis et al, 2002). *Moringa* oil utilized as a frying oil can be a healthy alternative to other commonly
The genus *Moringa* is indigenous to several countries. These countries include Madagascar, Namibia, SW Angola, Kenya, Ethiopia, Somalia, India, Pakistan, Bangladesh and Afghanistan in the northwestern region of the Himalayans (Fahey, 2005). It is potentially one of the planet’s most valuable plants, at least in humanitarian nutritional and medicinal terms and perhaps the fastest growing useful tree; it commonly tops 3 m to 5m within a year of the seed being placed in the ground. *Moringa* typically grows in semi-dry, desert or tropical soil that is why it grows well in many countries that normally have dry soils.

*Moringa Oleifera* and *Moringa Stenopetala* are the two most common species among the 13 species of the *Moringa* family. Both species have many characteristics in common. Both have similarity for use as a vegetable and water purifier. They share several medicinal uses and both have high contents of oil in the seeds: between 32 - 42 %. *Moringa Oleifera* has a faster development and yields fruits and seeds quickly. Whereas *Moringa Stenopetala* is better suited to a drier climate; yields of seeds are higher and they have a higher coagulant content (Bosch, 2004). While *Moringa Oleifera* originates from the Himalaya, *Moringa Stenopetala* is endemic to East Africa, where it occurs in northern Kenya and in Ethiopia. The two most common English vernacular names for the tree are ‘drumstick’ (describing the shape of its pods) and ‘horseradish’.

*Moringa* is already an important crop in India, Ethiopia, the Philippines and the Sudan, and is being grown in West, East and South Africa, tropical Asia, Latin America, the Caribbean, Florida and the Pacific Islands. All parts of the *Moringa* tree are edible and have long been consumed by humans. Some of the many uses for *Moringa* include: alley cropping (biomass production), animal forage (leaves and treated seed-cake), biogas (from leaves), domestic cleaning agent (crushed leaves), blue dye (wood), fencing (living trees), fertilizer (seed-cake), foliar nutrient (juice expressed from the leaves), green manure (from leaves), gum (from tree trunks), honey- and sugar cane juice-clarifier (powdered seeds), honey (flower nectar), medicine (all plant parts), ornamental plantings, biopesticide (soil incorporation of leaves to prevent seedling damping off), pulp (wood), rope (bark), tannin for tanning hides (bark and gum), water purification (powdered seeds). *Moringa* seed oil (yield 30-40% by weight), also known as Ben oil, is a sweet non-sticking, non-drying oil that resists rancidity. It has been used in salads, for
1. Introduction

Over 143 million children under the age of five in developing countries were undernourished in 2006 (UNICEF, 2007). Food insecurity, lack of access to health care (including international food aid), and social, cultural, and economic class, all play a major role in explaining the prevalence of under-nutrition (West et al., 2006). The regions most burdened by under-nutrition, (in Africa, Asia, Latin America, and the Caribbean) all share the ability to grow and utilize an edible plant, *Moringa*, commonly referred to as “The Miracle Tree” (Palada, 1996; Fuglie, 1999; Orwa et al., 2009). For hundreds of years, traditional healers have prescribed different parts of *Moringa* for treatment of skin diseases, respiratory illnesses, ear and dental infections, hypertension, diabetes, cancer treatment, water purification, and have promoted its use as a nutrient dense food source (Anwar et al., 2007; Fahey, 2005; Fuglie, 1999). The leaves of *Moringa* have been reported to be a valuable source of both macro- and micronutrients and is now found growing within tropical and subtropical regions worldwide, congruent with the geographies where its nutritional benefits are most needed.

Cultural prove of benefits from *Moringa*, particularly *M. Oleifera* has fueled a recent increase in adoption of and attention to its many healing benefits (Fahey, 2005), specifically the high nutrient composition of the plants leaves and seeds. Trees for Life, an NGO based in the United States has promoted the nutritional benefits of *Moringa* around the world, and their nutritional comparison has been widely copied and is now taken on faith by many: “Gram for gram fresh leaves of *M. Oleifera* have 4 times the vitamin A of carrots, 7 times the vitamin C of oranges, 4 times the calcium of milk, 3 times the potassium of bananas, ½ the iron of spinach, and 2 times the protein of yogurt” (Trees for Life, 2005). Other NGOs that have been active in promoting the use of *M. Oleifera* include, but are not limited to: ECHO (Florida, USA), Church World Service (Indiana, USA), GIANT (Georgia, USA), Helen Keller International (Guinea), and Santé et Nature (Congo).

Feeding animals *M. Oleifera* leaves results in both weight gain and improved nutritional status (Hunter & Stewart, 1993;; Sarwatt et al., 2004; Reyes-Sanchez et al., 2005; Kakengi et al., 2007). However, scientifically robust trials testing its efficacy for undernourished human beings have not yet been reported.
The genus Moringa is indigenous to several countries including Ethiopia. It contains many nutrients such as essential vitamins, essential minerals, amino acids, beta-carotene, antioxidants, anti-inflammatory nutrients, phytochemicals and it also contains both omega-3 and omega-6 fatty acids. The leaves are highly nutritious, being a significant source of beta-carotene, Vitamin C, protein, iron, and potassium. It is utilized in many developing countries where malnutrition is a major concern. Due to the high monounsaturated to saturated fatty acid ratio, Moringa seed oil could be considered an acceptable substitute for highly monounsaturated oils such as olive oil. The Moringa tree has a compound leaf; one leaf is made up of multiple leaflets. Harvesting can also be done by removing the leaves, picking them directly off the tree. Moringa oil utilized as a frying oil can be a healthy alternative to other commonly used oils such as palm, canola, and soybean oil when comparing fatty acid composition. People in many countries have used Moringa leaves as traditional medicine for common ailments. The bark, sap, roots, leaves, seeds, oil, and flowers are used in traditional medicine in several countries. It is used for intestinal worms, skin infections and sores, anemia, glandular swelling and lactating problems, etc. Moringa Oleifera is known to naturally boost the immune system, which usually becomes compromised in those suffering from type I and type II diabetes and research also revealed that, it has anti-tumor capacity to prevent cancer. Therefore the mission of popularizing Moringa and its products is to reduce poverty and malnutrition in developing countries through improved production and consumption.
4. CONCLUSION

- Nutritional variations was observed among the samples obtained from different regions
- Could be attributed to the genetic background of the plant, in terms of ecotype and cultivar, environmental factors
- This include the soil and climate (Sanchez-Machado et al., 2009)
- *M. Stenopetala* leaves are rich in nutrients and has potential to be used as protein and mineral resource for animal and human food formulations
- Drying the leaves assists to concentrate and reduce some of the antinutritional factors
- *M. Stenopetala* leaves in Ethiopia has comparable and appreciable nutritional profile as *M. Oleifera*
- Processing is required to reduce the phytate content so that minerals like Zinc can be used by the body during consumption
- Statistically significant difference in the mean values of all nutrition composition parameters between study regions—Tigray, Amhara, Oromia, SNNPR and Dire Dawa—except for tannin content of the samples.
- *M. stenopetala* species of Moringa tree in Ethiopia has appreciable nutritional profile which can be of a great input to fight the long overdue malnutrition problem in Ethiopia with appropriate processing
Comparison of *M. Stenopetala* with *M. Oleifera* (Minerals)

<table>
<thead>
<tr>
<th>Species</th>
<th>Fe</th>
<th>Ca</th>
<th>Zn</th>
<th>Cu</th>
<th>P</th>
<th>K</th>
<th>Na</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. Stenopetala</em></td>
<td>54.85</td>
<td>1,918.0</td>
<td>2.16</td>
<td>0.78</td>
<td>38.19</td>
<td>2,094.5</td>
<td>214.10</td>
</tr>
<tr>
<td><em>M. Oleifera</em> (Local)</td>
<td>82.40</td>
<td>1,765.9</td>
<td>1.78</td>
<td>1.06</td>
<td>34.49</td>
<td>1,928.07</td>
<td>249.75</td>
</tr>
<tr>
<td><em>M. Oleifera</em> (Odúro I. et al, 2008, Kumasi, Ghana)</td>
<td>28.29</td>
<td>2,009.79</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>M. Oleifera</em> (Charles W.Y. et al, 2011, Oungadougou, Burkina Faso)</td>
<td>17.5</td>
<td>2,098</td>
<td>1.3</td>
<td>-</td>
<td>111.5</td>
<td>549.6</td>
<td>-</td>
</tr>
</tbody>
</table>
Comparison of *M. Stenopetala* with *M. Oleifera* (Proximate and energy)

<table>
<thead>
<tr>
<th>Species</th>
<th>Moisture (%)</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Crude fiber (%)</th>
<th>Ash (%)</th>
<th>Carbohydrate (%)</th>
<th>Energy (kcal/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. Stenopetala</em></td>
<td>8.09</td>
<td>28.44</td>
<td>0.70</td>
<td>11.62</td>
<td>12.63</td>
<td>38.49</td>
<td>274.1</td>
</tr>
<tr>
<td><em>M. Oleifera</em> (Local)</td>
<td>7.02</td>
<td>25.57</td>
<td>0.34</td>
<td>8.51</td>
<td>11.81</td>
<td>46.76</td>
<td>292.40</td>
</tr>
<tr>
<td><em>M. Oleifera</em> (Oduro I. et al, 2008, Kumasi, Ghana)</td>
<td>27.51</td>
<td>2.23</td>
<td>19.25</td>
<td>7.13</td>
<td>43.88</td>
<td>305.6</td>
<td></td>
</tr>
<tr>
<td><em>M. Oleifera</em> (Charles W.Y.et al, 2011, Ouagadougou, Burkina Faso)</td>
<td>5.9</td>
<td>27.1</td>
<td>17.1</td>
<td>19.4</td>
<td>11.1</td>
<td>38.6</td>
<td>339.1</td>
</tr>
</tbody>
</table>
Antinutritional factors

*Mean±SE*

<table>
<thead>
<tr>
<th>Region</th>
<th>N</th>
<th>Phytate</th>
<th>Tanin</th>
<th>Phy:Fe molar ratio</th>
<th>Phy:Zn molar ratio</th>
<th>Phy:Ca Molar ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tigray</td>
<td>8</td>
<td>419.01±17.53</td>
<td>455.98±117.64</td>
<td>0.67±.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>20.72±0.92</td>
<td>0.011±.0009</td>
</tr>
<tr>
<td>Amhara</td>
<td>12</td>
<td>302.53±36.86</td>
<td>272.95±17.39</td>
<td>0.74±.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.46±1.94</td>
<td>0.013±.0013</td>
</tr>
<tr>
<td>Oromia</td>
<td>6</td>
<td>356.31±29.87</td>
<td>462.68±28.10</td>
<td>0.62±.01&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>15.56±0.61</td>
<td>0.010±.0014</td>
</tr>
<tr>
<td>SNNPR</td>
<td>8</td>
<td>459.01±13.44</td>
<td>284.65±84.39</td>
<td>0.76±.07&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>19.05±1.63</td>
<td>0.012±.0006</td>
</tr>
<tr>
<td>Dire Dawa</td>
<td>4</td>
<td>397.13±31.89</td>
<td>415.39±7.70</td>
<td>0.40±.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>20.57±2.74</td>
<td>0.014±.0018</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>378.44±16.53</td>
<td>358.89±32.92</td>
<td>0.67±.04</td>
<td>17.56±0.87</td>
<td>0.012±.0005</td>
</tr>
</tbody>
</table>

- If Phy:Zn >15, Phy:Fe > 1 and Phy:Ca > 0.24 then, the bioavailability of the mineral is low
  - Phy:Fe =0.67±.04 Below the cutoff point
  - Phy:Zn =17.56±0.87 Above the cutoff point
  - Phy:Ca =0.012±.0005 Below the cutoff point
• The mean ratio of potassium to sodium was found to be 9.78 which is a good characteristic if consumed by individuals with hypertension and heart problems.
## Mineral content

### Mean±SE

<table>
<thead>
<tr>
<th>Region</th>
<th>N</th>
<th>Fe</th>
<th>Ca</th>
<th>Zn</th>
<th>Cu</th>
<th>P</th>
<th>K</th>
<th>Na</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tigray</td>
<td>8</td>
<td>65.84±11.73&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>2244.9±155.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.01±0.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.82±0.12&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>49.31±1.11&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1699.9±99.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>250.33±26.41&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Amhara</td>
<td>12</td>
<td>34.85±3.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1413.2±137.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.10±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.94±0.22&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>38.00±2.40&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2153.8±106.93&lt;sup&gt;b&lt;/sup&gt;</td>
<td>100.68±16.23&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Oromia</td>
<td>6</td>
<td>60.63±9.23&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>2156.5±215.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.23±0.10&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.64±0.12&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>33.08±1.73&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2070.0±15.61&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>263.17±41.25&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>SNNPR</td>
<td>8</td>
<td>55.25±6.12&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>2298.2±204.73&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.44±0.12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.39±0.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>39.32±2.28&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2274.2±163.47&lt;sup&gt;b&lt;/sup&gt;</td>
<td>314.67±39.30&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Dire Dawa</td>
<td>4</td>
<td>83.36±9.36&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1660.6±113.4&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.94±0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.18±0.09&lt;sup&gt;b&lt;/sup&gt;</td>
<td>21.94±3.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2383.2±118.78&lt;sup&gt;b&lt;/sup&gt;</td>
<td>207.14±6.34&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>54.85±4.11</td>
<td>1918.0±97.69</td>
<td>2.16±0.05</td>
<td>0.78±0.08</td>
<td>38.19±1.58</td>
<td>2094.5±63.19</td>
<td>214.10±18.32</td>
</tr>
</tbody>
</table>

- The content of potassium of the collected samples has been found appreciable with a mean value of 2,094.5 mg/100gm where as the sodium content was found to be 214.10mg/100gm.
### Proximate and Energy content

#### Mean±SE

<table>
<thead>
<tr>
<th>Region</th>
<th>N</th>
<th>Moisture</th>
<th>Protein</th>
<th>Fat</th>
<th>Crude fiber</th>
<th>Ash</th>
<th>Carbohydrate</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tigray</td>
<td>8</td>
<td>9.13±.12c</td>
<td>28.28±1.14ab</td>
<td>0.76±0.08b</td>
<td>11.24±0.64abc</td>
<td>10.21±0.26b</td>
<td>40.35±1.23bc</td>
<td>281.43±2.58b</td>
</tr>
<tr>
<td>Amhara</td>
<td>12</td>
<td>8.17±.30ab</td>
<td>27.08±0.67ab</td>
<td>0.66±0.08b</td>
<td>12.22±0.27bc</td>
<td>12.06±0.48ab</td>
<td>39.79±0.92bc</td>
<td>273.43±2.65b</td>
</tr>
<tr>
<td>Oromia</td>
<td>6</td>
<td>8.35±.15bc</td>
<td>26.92±1.1a</td>
<td>0.90±0.18b</td>
<td>9.81±0.58a</td>
<td>12.34±0.11b</td>
<td>41.66±1.47c</td>
<td>282.41±2.59b</td>
</tr>
<tr>
<td>SNNPR</td>
<td>8</td>
<td>7.60±.19ab</td>
<td>31.15±1.78c</td>
<td>0.30±0.04a</td>
<td>12.92±0.58c</td>
<td>14.94±0.96c</td>
<td>33.07±0.77a</td>
<td>259.64±5.16a</td>
</tr>
<tr>
<td>Dire Dawa</td>
<td>4</td>
<td>6.39±0.02a</td>
<td>29.75±1.45ab</td>
<td>1.22±0.16c</td>
<td>10.64±0.65abc</td>
<td>14.98±0.93c</td>
<td>36.98±1.60b</td>
<td>278.02±2.26b</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>8.09±.16</td>
<td>28.44±.58</td>
<td>0.70±0.06</td>
<td>11.62±0.27</td>
<td>12.63±0.39</td>
<td>38.49±0.69</td>
<td>274.11±2.00</td>
</tr>
</tbody>
</table>
- One way ANOVA, Region and city administration being the factor (Amhara, Oromia, SNNPR, Dire Dawa, Tigray)
- Mean values, standard errors calculated

- Comparison of the result
  - The mean moisture content of the dried samples was 8.09 %
  - The mean value of the protein content was 28.44%
    - Samples from SNNPR having statistically significant edge over the other regions with a mean value of 31.15%.
  - Mean fat content of the regions was 0.7%
    - Dire Dawa have the highest: 1.22%