

THE MORINGA TREE

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ECHO TECHNICAL NOTE

INTRODUCTION

The moringa tree, *Moringa oleifera*, has probably been the most popular plant in ECHO's seedbank of underutilized tropical crops. The tree is native to India but has been planted around the world and is naturalized in many locales. Moringa goes by many names. In the Philippines, where the leaves of the moringa are cooked and fed to babies it is called "mother's best friend" and "malunggay." Other names for it include the benzolive tree (Haiti), horseradish tree (Florida), Nébéday (Senegal) and drumstick tree (India).

There are about 13 species of moringa trees in the family Moringaceae. They are native to India, the Red Sea area and/or parts of Africa including Madagascar. *Moringa oleifera* is the most widely known species, but other species deserve further research as to their uses. In this document, when we mention "moringa" we are referring to *M. oleifera*. All other species we refer to using the Latin name.

USES OF MORINGA

LEAVES



The leaflets can be stripped from the feathery, fern-like leaves and used in any spinach recipe and are exceptionally nutritious. Very young plants can also be used as a tender vegetable. In many cultures the diet consists mainly of a starchy dish or porridge made from corn meal, cassava, millet or the like. Side dishes or "sauces" served with the starchy main dish are therefore very important nutritionally, often being the only source of extra protein, vitamins and minerals. Moringa leaves could easily be added to such sauces as a potherb or as dried herbs.

Frank Martin states in *Survival and Subsistence in the Tropics* that "among the leafy vegetables, one stands out as particularly good, the horseradish tree. The leaves are outstanding as a source of vitamin A and, when raw, vitamin C. They are a good source of B vitamins and among the best plant sources of minerals. The calcium content is very high for a plant. Phosphorous is low, as it should be. The content of iron is very good (it is reportedly prescribed for anemia in the Philippines). They are an excellent source of protein and a very low source of fat and carbohydrates. Thus the leaves are one of the

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best plant foods that can be found." In his *Edible Leaves of the Tropics* he adds that the leaves are incomparable as a source of the sulfur-containing amino acids methionine and cystine, which are often in short supply.

Dennis Rempel in Burkina Faso reported on seed ECHO had sent. "Folks loved the leaves. In fact it is supposedly found locally, though I have yet to be shown any. They say it is rare but highly prized to be added to sauces. Everyone wants more."

In Senegal and Haiti, health workers have been treating malnutrition in small children and pregnant and nursing women with moringa leaf powder. The results have been very satisfactory (See below, as written in *ECHO Development Notes (EDN) 64*). The Senegal project is written up in a book, *Moringa oleifera: Natural Nutrition for the Tropics* by Lowell Fuglie and is available from ECHO in English and French (*L'Arbre de la Vie*). A video made by Lowell Fuglie on the project is also available from ECHO.

An Impressive Moringa Project in Senegal

Adapted by Martin Price from a Church World Service report by Lowell Fuglie

Lowell Fuglie with Church World Service (CWS) in Senegal sent us a report on a recent CWS project called Moringa oleifera: Natural Nutrition for the Tropics. ECHO and others have published articles about the many uses, nutritional content and hardiness of this drought-resistant "vegetable tree." This report contains valuable technical information and adds an important human face by reporting results of an evaluation of the project and interviews with people who have benefited from it.

A Fresh Look at Nutrition and Moringa

People have different nutritional requirements at different stages of their lives. Lactating women and weaned children ages 1-3 are especially vulnerable in areas where malnutrition is commonplace. This report lists the recommended daily allowance (RDA) for the major nutrients for children ages 1-3 and for lactating women and compares this to the amount of these nutrients present in moringa pods, moringa leaves and moringa leaf powder.

Here are highlights from several tables. "For a child aged 1-3, a 100 g serving of fresh cooked leaves would provide all his daily requirements of calcium, about 75% of his iron and half his protein needs, as well as important amounts of potassium, B vitamins, copper and all the essential amino acids. As little as 20 grams of leaves would provide a child with all the vitamins A and C he needs."

"For pregnant and breast-feeding women, moringa leaves and pods can do much to preserve the mother's health and pass on strength to the fetus or nursing child. One 100 g portion of leaves could provide a woman with over a third of her daily need of calcium and give her important quantities of iron, protein, copper, sulfur and B-vitamins."

Moringa leaves can be easily dried (in the shade to reduce loss of vitamins) and rubbed over a wire screen to make a powder, which can be stored and conveniently added to soups, sauces, etc. "It is estimated that only 20-40% of vitamin A will be retained if leaves are dried under direct sunlight, but that 50-70% will be retained if leaves are dried in the shade." "One rounded tablespoon (8 g) of leaf powder will satisfy about 14% of the protein, 40% of the calcium, 23% of the iron and nearly all the vitamin A needs for a child aged 1-3. Six rounded spoonfuls of leaf powder will satisfy nearly all of a woman's daily iron and calcium needs during pregnancy and breast-feeding."

During pregnancy and breast-feeding, women are most at risk of suffering from nutritional deficiencies. The table below shows the percent of the RDA of various nutrients for a nursing mother eating six rounded tablespoons (about 50 g) of leaf powder daily. It also shows the percent of the RDA for a 1-3 year old child with one rounded tablespoon of powder added to its food, three times daily.

	<i>Mother</i>	<i>Child</i>
<i>Protein</i>	21%	42%
<i>Calcium</i>	84%	125%
<i>Magnesium</i>	54%	61%
<i>Potassium</i>	22%	41%
<i>Iron</i>	94%	71%
<i>Vitamin A</i>	143%	272%
<i>Vitamin C</i>	9%	22%

How the Program Operated

Lowell says he first became aware of the nutritional value of moringa from reading EDN. He did not need to order seeds from our seedbank, however, because moringa already grew wild in Senegal. It was seldom eaten, and much of the nutritional content was lost when it was prepared due to the common practice of boiling the leaves then discarding the water, as many as three times.

The project began in early 1997. CWS partnered with a local NGO, Alternative Action for African Development (AGADA). Together they trained a network of government health workers (doctors, nurses, midwives) in ways of using moringa. Informational booklets, brochures, a seminar and radio spots were put together.

An outside evaluation of the project was conducted in December 1998. They interviewed 70 individuals. Answers to the questions posed follow, based on their report.

Would moringa leaves, leaf powder and pods be effective in treating malnutrition and promoting physical health and well being? "Successful treatment of malnourished children has been well-documented. Interviews with men and women who have made moringa a regular part of their diets point out that they have a keen awareness of improvements in their health and energy. At one health post, the pharmacy is now selling moringa leaf powder to mothers with malnourished children (US 5 cents per sachet)."

There is limited awareness of nutrition and the importance of balanced diets. Would people see the value of adding moringa to their foods as a purely nutritional measure? "It is apparent that one does not need an education in nutrition to know whether or not one is feeling healthy. People expressed every intention of continuing to include moringa in their diets because of the sense of physical well-being it gives them. In one village virtually every household now maintains a stock of moringa leaf powder."

Would people be receptive to changing the way they prepared fresh moringa leaves? "Traditionally leaves are boiled 2-3 times and the water discarded after each boiling to remove some of the bitter taste. However, some individuals claim they are no longer discarding the water or boiling the leaves more than once. In addition, making sauces with leaf powder instead of fresh leaves appears to be quite popular because it saves time and is easy to use."

Would they be receptive to adding new foods, such as moringa pods, to their diets? "This has been surprisingly successful, since new foods are often very difficult to introduce in West Africa. People interviewed have shown considerable inventiveness when it comes to preparing moringa pods, seeds and flowers."

Would local consumption remain dependent on outside encouragement and training, or could it develop spontaneously? "Partly thanks to radio broadcasts about moringa, partly through training provided local communities by some of the more dynamic health agents, and partly through word-of-mouth and example, moringa and its properties are gradually becoming known even outside the project's target area. The project directly sponsored planting 10,000 trees in 1998, but it is likely that a similar number were planted by individuals within the region."

As I read through excerpts from interviews I selected a few to share here. The supervisor of the primary health department at a hospital said, "We have always had problems with the classical approach to treating malnourished children. This was based on industrial products: whole milk powder, vegetable oil and sugar. All these things are expensive. When you tell a parent to go out and buy them—this can be truly costly for them."

A nurse in charge of pediatrics at a hospital keeps dried leaf powder on hand to give out to mothers of malnourished children.

An administrator at another general hospital is a diabetic. "I have for the past three years been controlling my blood sugar by periodically drinking a tea made from moringa leaves." He decided to plant a thousand trees around the hospital complex. "This way we will always have a ready supply of leaves to treat the cases of malnutrition we receive." [Editor: We know nothing about the value of moringa tea for diabetes. Have others heard of this?]

One of the mothers said, "At first, when I tried to nurse my son, I was not producing enough milk. Then I started to eat moringa. After a short while I had enough milk again. We now eat moringa sauces at least three times a week. Every other time I had a baby, I lost weight during the months I was breast-feeding. This time I have been gaining weight."

Many adults mentioned that they were no longer so tired. Some mentioned that they and their children sleep better. One said that "After we boil the pods, we distribute the water and drink it. It tastes sugary." There were some accounts of children vomiting worms the first time they were fed moringa.

This 68-page book also contains many recipes. There are many pictures of the people being interviewed, which might be helpful in proposing a similar project to local leaders in other countries.

The book is available from ECHO in English or French for \$9.95 (plus postage: North America \$2; airmail to Latin America \$3 and elsewhere \$5). The video is also \$9.95 plus the same shipping rates. You can write Lowell Fuglie at Church World Service; 12 rue Felix Faure; B. P. 3822; Dakar, Senegal, West Africa or e-mail at fuglie@sonatel.senet.net.

Moringa leaf powder is made by drying the leaves in the shade (drying them in the sun will cause loss of vitamin A). The brittle dried leaves are then pounded, and sifted to remove leaf stems. The powder should be stored in a sealed dark container. Spoonfuls of the powder can then be added to baby food, soups, and vegetables, adding nutrition but not changing the taste.

Moringa leaves are not always available throughout the whole year. *M. stenopetala* is deciduous in some of its native range. In West Africa moringa leaves appear at the end of the dry season, when there are few other sources of leafy green vegetables. Leaf drop varies depending on climate and rainfall.

MORINGA OLEIFERA			
NUTRITIONAL VALUE OF LEAVES AND PODS			
Analysis of Moringa pods, fresh (raw) leaves and dried leaf powder have shown them to contain the following per 100 grams of edible portion:			
	<u>Pods</u>	<u>Leaves</u>	<u>Leaf Powder</u>
Moisture (%)	86.9	75.0	7.5
Calories	26	92	205
Protein (g)	2.5	6.7	27.1
Fat (g)	0.1	1.7	2.3
Carbohydrate (g)	3.7	13.4	38.2
Fiber (g)	4.8	0.9	19.2
Minerals (g)	2.0	2.3	-
Ca (mg)	30	440	2,003
Mg (mg)	24	24	368
P (mg)	110	70	204
K (mg)	259	259	1,324
Cu (mg)	3.1	1.1	0.57
Fe (mg)	5.3	7	28.2
S (mg)	137	137	870
Oxalic acid (mg)	10	101	1.6%
Vitamin A - B carotene (mg)	0.11	6.8	16.3
Vitamin B -choline (mg)	423	423	-
Vitamin B1 -thiamin (mg)	0.05	0.21	2.64
Vitamin B2 -riboflavin (mg)	0.07	0.05	20.5
Vitamin B3 -nicotinic acid (mg)	0.2	0.8	8.2
Vitamin C -ascorbic acid (mg)	120	220	17.3

Vitamin E -tocopherol acetate (mg)	-	-	113
Arginine (g/16g N)	3.6	6.0	1.33%
Histidine (g/16g N)	1.1	2.1	0.61%
Lysine (g/16g N)	1.5	4.3	1.32%
Tryptophan (g/16g N)	0.8	1.9	0.43%
Phenylalanine (g/16g N)	4.3	6.4	1.39%
Methionine (g/16g N)	1.4	2.0	0.35%
Threonine (g/16g N)	3.9	4.9	1.19%
Leucine (g/16g N)	6.5	9.3	1.95%
Isoleucine (g/16g N)	4.4	6.3	0.83%
Valine (g/16g N)	5.4	7.1	1.06%

From *Moringa oleifera: Natural Nutrition for the Tropics* by Lowell Fuglie

The B-carotene found in moringa is a precursor to retinol (Vitamin A). There are around 25 kinds of B-carotene. Efficiency of retinol production varies among types. Research is still required to know more about the B-carotene types in moringa leaves and their efficiency in transforming carotene to retinol, as well as the losses or inactivation due to various moringa processing methods.

Moringa Leaf Extract As A Plant Growth Hormone

Juice from fresh moringa leaves can be used to produce an effective plant growth hormone, increasing yields by 25-30% for nearly any crop: onions, bell pepper, soya, maize, sorghum, coffee, tea, chili, melon . . . One of the active substances is Zeatin: a plant hormone from the Cytokinines group. This foliar spray should be used in addition to (and not in lieu of) other fertilizers, watering and sound agricultural practices.

In one trial, use of this spray increased maize yields from 60 to 130 sacks per hectare. Using this hormone, BIOMASA was able to grow coffee at 30 meters altitude. Coffee, shaded with *Jatropha curcas*, produced beans in just 17 months.

Here is how they make the spray:

- a) Make an extract by grinding young moringa shoots (not more than 40 days old) together with a bit of water (about one liter per 10 kg fresh material).
- b) Filter the solid out of the solution. This can be done by placing the solution in a cloth and wringing out the liquid. The solid matter, which will contain 12-14% protein, can be used as livestock feed.
- c) Dilute the extract with water at a 1:32 ratio and spray directly onto plants (if the extract is not going to be used within five hours, it is best stored in a freezer until needed). Apply about 25 ml per plant.

The foliar spray should be applied 10 days after the first shoots emerge from the soil, again about 30 days before plants begin to flower, again when seed appears and finally once more during the maturation phase.

Moringa Shoots As Green Manure

Using moringa as a green manure can significantly enrich agricultural land. In this process, the land is first tilled. Moringa seed is then planted 1-2 cm deep at a spacing of 10x10 cm (a density of one million seed per hectare). The density can be greater. The only limits to plant density are availability of seed, water and fertilizer. After 25 days, the seedlings are plowed into the soil to a depth of 15 cm. The land is prepared again for the crop desired.

Seeding can be done mechanically if the seed is first de-hulled. Planting kernels will reduce germination time by up to three days.

A simple method of seeding is to first rototill the soil to a depth of 10 cm, then scatter seed over the soil and rototill again to a depth of 2-3 cm.

Leaves are excellent for biogas production.

Intensive Moringa Leaf Production

Whether produced for use as a green manure, for livestock or for human consumption, moringa can be grown intensively with yields of up to 650 metric tons of green matter per hectare. This compares very well to other green manure crops such as lablab beans, which yield up to 110 tons/hectare of green matter in pure stands.

These high yields were obtained through subsoiling to a depth of 60 cm (to encourage drainage and good root development), rotavating, then planting moringa at a 10x10 cm density (one million plants per hectare) with sufficient fertilizer (cow dung is preferred). BIOMASA did sub-soiling with a deep plugging unit produced by a German company called HOWARD (unit costs US\$8,000 and requires a 150 HP tractor).

The green matter is harvested when plants reach a height of 50 cm or more (every 35-40 days), cut at a distance of 15-20 cm above the ground. Although losses of seedlings may be 20-30% in the first year, the vigorous regrowth of the remaining seedlings will produce 3 or 5 new shoots after each cutting. Up to nine harvests can be obtained annually. In time (some of BIOMASA's moringa stands are three years old) the 15-20 cm stem will become thick and woody but will continue to send up green shoots.

The 650 metric ton yield was obtained in sandy, well-drained soil at 30 meters altitude. Rainfall was 1300 mm annually with irrigation practiced during the dry season. At this level of production, the nutrient requirement per hectare each year is:

1,800 kg Calcium	0.5 kg Copper
1,400 kg Magnesium	380 kg Phosphorus
0.6 kg Boron	280 kg Nitrogen
0.3 kg Zinc	

For bulk orders, local fertilizer producers can mix this to order. Barring that, adding urea to existing fertilizers can provide many of the needed nutrients. [Ed.: Note that the soils in other locations may be able to provide a portion of these requirements and fertilizer needs may be different.]

Moringa As Livestock Feed

BIOMASA conducted extensive trials using moringa leaves as cattle feed (beef and milk cows), swine feed, and poultry feed. With moringa leaves constituting 40-50% of feed, milk yields for dairy cows and daily weight gains for beef cattle increased 30%. Birth weight, averaging 22 kg for local Jersey cattle, increased by 3-5 kg.

The high protein content of moringa leaves must be balanced with other energy food. Cattle feed consisting of 40-50% moringa leaves should be mixed with molasses, sugar cane, young elephant grass, sweet (young) sorghum plants, or whatever else is locally available. The maximum protein and fiber content of livestock feed should be:

	<u>Protein</u>	<u>Fiber</u>
Lactating cow:	18%	26-30%
Beef cow:	12-14%	36%
Lactating sow:	16-18%	5-7%
Meat pig:	12-14%	5-7%

Care must be taken to avoid excessive protein intake. Too much protein in pig feed will increase muscle development at the expense of fat production. In cattle feed, too much protein can be fatal (from alteration of the nitrogen cycle).

Nutrient value of moringa leaves can be increased for poultry and swine through the addition of an enzyme (phytase) to break down the phytates, leading to increased absorption of the phosphorus found in moringa. The enzyme should be simply mixed in with the leaves without heating. It is NOT for use with ruminants. [Companies that sell phytase include Roche (Hoffman-LaRoche), which has distributors worldwide. ECHO was quoted a price of US\$6.40/kg of Ronozyme™ P (also sold as Roxazyme™ in some regions). One kilo of enzyme at that concentration can treat 3333 kg of broiler chicken feed, the same amount of swine feed, or 5555 kg layer chicken feed. If you don't know of a local Roche dealer you can find one on the internet at www.roche.com/vitamins/areas.html or write to their mail order address at Roche Vitamins Inc., PO Box 910, Nutley, NJ 07110-1199, USA.]

Cattle were fed 15-17 kg of moringa daily. Milking should be done at least three hours after feeding to avoid the grassy taste of moringa in the milk.

With moringa feed, milk production was 10 liters/day. Without moringa feed, milk production was 7 liters/day.

With moringa feed, daily weight gain of beef cattle was 1,200 grams/day. Without moringa feed, daily weight gain of beef cattle was 900 grams/day.

The higher birth weight (3-5 kg) can be problematic for small cattle. It may be advisable to induce birth 10 days prematurely to avoid problems. Incidence of twin births also increased dramatically with moringa feed: 3 per 20 births as opposed to the usual average of 1:1000.

Moringa Leaf Concentrate

Chickens will not voluntarily consume moringa leaves or moringa leaf powder. However, about half the protein content can be extracted from the leaves in the form of a concentrate which can then be added to chicken feed (or used in many other ways). The protein content desired in chicken feed is 22%. To obtain the concentrate, mix leaves with water and run the mix through a hammer mill. Heat this mash to 70 degrees Celsius for 10 minutes. The protein will clump and settle to the bottom. After pouring off the liquid, this can then be freeze-dried.

A somewhat simpler alternative to freeze-drying is to take a pressure cooker and fit in the top a copper tube or steel tube. Take a compressor from an old refrigerator. Link the tube to the compressor inlet and run the compressor. At a temperature of 300 C and about 50 mm of vacuum you can take out most of the water by evaporation in vacuum (in case you need it dry).

But if you wish to use it as a fresh fodder just take the sludge after sedimentation and mix it with dry fodder until you can handle it as a semidry mass. Then press it through a meat grinder to make homemade pellets. For pig fodder just mix the pellets with the normal fodder (be careful not to overdo it - fattening pigs need 12-14% and lactating pigs 16-18% protein).

PODS

The young pods, also known as "drumsticks" by Indian communities, are cooked and reportedly have a taste like asparagus. They are sold fresh and canned in many Asian markets. Tinned drumsticks are exported from India, Sri Lanka and Kenya to Europe and Asia. They are eaten much like green beans. The green peas and surrounding white material can be removed from larger pods and cooked in various ways.

FLOWERS

After about 8 months to a year, the tree begins to flower and continues year round. The flowers can be eaten or used to make a tea. In Haiti tea from the flowers is drunk for colds. The flowers provide good amounts of both calcium and potassium. Moringa flowers are also good for beekeepers since they provide a year-round source of nectar.

SEED



Seed can be extracted and eaten as "peas" (boiled or fried) when still green.

The mature seed is about 40% oil. Moringa oil is of excellent quality (73% oleic acid, similar to olive oil) for cooking. Sold for many years as "ben oil," it is used in cooking, perfumes and as a watch lubrication. It became a substitute for sperm oil. It is used for making soap and for light as well. The oil is slow to become rancid. The species *M. peregrina* from the Red Sea area reportedly produces a very good oil.

Moringa Seed Oil Extraction

Oil can be extracted from moringa seed in the home. Seed from mature pods (which can be two feet long) are roasted, mashed and placed in boiling water for five minutes. After straining and sitting overnight, the moringa oil floats to the surface.

Footsteps magazine (Issue 28) describes the oil extraction process:

Moringa seed has a fairly soft kernel, so the oil can be extracted by hand using a screw press (also known as a "spindle" or "bridge" press). The seed is first crushed, 10% by volume of water is added, followed by gentle heating over a low fire for 10-15 minutes, taking care not to burn the seed. One such test yielded 2.6 litres of oil from 11 kg of kernels. Once the best processing conditions are worked out, an extraction efficiency of 65% could probably be expected.

Nikolaus Foidl designed a motorized moringa seed de-huller with a built-in blower to separate out the chaff. The de-hulling part of the machine consists of two revolving rubber plates slightly oval in shape. Seed is run through 3 times, with the space between the plates diminished slightly each time (smaller seed not de-hulled the first time will be de-hulled the 2nd or 3rd time).

Nikolaus suggests that a screw press made of simple iron may be better suited to moringa oil extraction than one made of steel. Chromium and nickel in the steel may react with the oil and lower oil quality. One possibility is the FAKT press, a German-designed oil press now produced in India, which BIOMASA has successfully used to extract *Jatropha* oil. The FAKT press costs about US\$1400 and will process 80-90 kg/hour. [Contact FAKT - Associated Consultants, Stephan Blattman Str. 11, 78120 Furtwangen, Germany; phone: +49 7723 91 20 63; fax: +49 7723 53 73; e-mail: ReiMetzler@aol.com.]

Following extraction, moringa oil should be filtered (through cheese cloth or coffee filter). This will remove the protein content upon which bacteria feed. Viscosity of oil can be improved by heating it to 40-50° C before filtering.

At Church World Service in Senegal, one oil extraction trial used kernels that had been de-hulled three months earlier. The oil promptly separated into a milky wax and liquid. According to Foidl, this was probably due to

the rapid deterioration in the stored kernels of the anti-oxidant vitamin E. A few (1-5) drops per liter of the essential oil of sage, rosemary or mint (or a twig of the latter), both excellent anti-oxidants, can be added to moringa oil to stabilize it. (Trials can be done to determine at what point the taste of the sage or rosemary oil becomes noticeable.)

Water Treatment

Among other achievements, BIOMASA installed a water treatment system using moringa seed powder in one village in Nicaragua. BIOMASA also isolated the active ingredient, a polyelectrolyte, in the laboratory. One hundred kg of moringa kernels will produce about 1 kg of (almost pure) polyelectrolyte.

BIOMASA found that the level of polyelectrolyte present in the kernels is substantially less during the wet season. (This may explain why, in CWS's work in Senegal, a water treatment experiment done last September failed to work!) Seed harvested for water treatment should be harvested during the dry season only.

The seedcake left over after the oil extraction process has several uses. It can be used as soil fertilizer or in the treatment of turbid water. It is being researched as an animal feed, but certain antinutritional factors must be dealt with before it is suitable for feeding livestock.

Seed powder from ground-up seed and also the presscake left over from oil extraction can both be used for the treatment of turbid water. Dr. Samia Al Azharia Jahn with the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) in Germany told ECHO how to use moringa seeds to clarify water. Suspensions of the ground seed of the benzolive tree are used as primary coagulants. They can "clarify Nile water of any degree of visible turbidity." At high turbidities their action was almost as fast as that of alum, but at medium and low turbidities it was slower. The doses required did not exceed 250 mg/l. Coagulating the solid matter in water so that it can be easily removed can remove a good portion of the suspended bacteria. "River water is always faecally polluted. At our sampling site the total coliforms amounted during the flood season to 1600-18,000 per 100 ml. Turbidity reductions to 10 FTU were achieved after one hour, reducing the coliforms to 1-200 per 100 ml." "Good clarification is obtained if a small cloth bag filled with the powdered seeds of the benzolive is swirled round in the turbid water."

To prepare the seed for use as a coagulant, remove the seed coats and the "wings." The white kernel is then crushed to a powder using a mortar or placing in a cloth on top of a stone and crushing. Two heaping teaspoons or two grams of the powder should be mixed with a small amount of clean water in a bottle. The water and moringa kernel powder should be shaken for five minutes to form a paste. This paste is then poured through a cloth strainer into the water to be purified. The water is stirred rapidly for two minutes, and then slowly for 10-15 minutes. Leave the bucket of water undisturbed for at least an hour. Impurities will then sink to the bottom. The water should be strained again into a storage container for use. This process removes 90-99% of impurities. If there is a possibility of disease in the water, it can be purified by chlorine, boiling or solarizing (placing in the direct sun in a clear bottle for two hours).

According to Lowell Fuglie, a general rule of thumb is that powder from one moringa kernel to two liters of water is a good amount when water is slightly turbid, and to one liter when water is very turbid. The seeds and powder can be stored but the paste needs to be fresh for purifying the water.

According to BIOMASA, seed powder can also be used to harvest algae from waste water, currently an expensive process using centrifuges. Spirolina algae is farmed in Mexico and Israel with minor production in other countries. The spirulina are used in health food and cosmetic products, and it is a common fish food ingredient. Seed powder will cause the algae to sink to the bottom. Once harvested, further drying can be done with a simple steam-heated drum dryer heated to 110°C to kill eggs, etc. In feeding fish, 100% of protein can come from algae sources. For cattle feed, however, at most 10% of protein content can be replaced with algae protein. It should also be cautioned that algae food or feed products can contain toxins from the water in which it was grown.

WOOD

Moringa wood is very soft. It is advocated by some as a good live fence tree though in ECHO's experience this has not proven so. It makes acceptable firewood but poor charcoal. According to Foidl, moringa wood makes excellent pulp - as good as poplar (*Populus* sp.).

The bark is sometimes used to make mats and rope. A blue dye is also made from the wood in Senegal and Jamaica.

ROOTS

Small trees a few months old can be pulled and the taproot ground, mixed with vinegar and salt and used in place of horseradish. I am told that when grown for its roots, the seeds are sometimes planted in a row like vegetables. At about 60 cm (24 in) in height the tree is harvested. Make sure the root bark is scraped off, as it contains two alkaloids and a toxin, moringinine. Eating large amounts of the root at once or too often should be avoided.

USE AS AN ANTIBIOTIC

A compound found in the flowers and roots of the moringa tree, pterygospermin, has powerful antibiotic and fungicidal effects. A study at University of San Carlos in Guatemala was summarized in *EDN 37 (Amaranth to Zai Holes p. 298)*.

Herbal applications are commonly used to treat skin infections in developing countries, although few investigations are conducted to validate scientifically their popular use. A previous study had showed that moringa seeds are effective against skin infecting bacteria Staphylococcus aureus and Pseudomonas aeruginosa in vitro (i. e. in a test tube). This study showed that mice infected with S. aureus recovered as quickly with a specially prepared aqueous extract of moringa seed as with the antibiotic neomycin. This study proves only the effectiveness of moringa as they prepared it. That preparation could be done in any country, but not with just household utensils. It was prepared by infusing 10 g powdered moringa seeds in 100 ml of 45°C (96° F) water for 2 hours. The part that is a bit more complicated is reducing the 100 ml down to 10 ml by placing it in a rotavaporator. This is a very common piece of laboratory equipment that continually rotates a flask containing the liquid. An aspirator producing a modest vacuum is connected to the rotavaporator, reducing the pressure and causing the water to evaporate rather quickly without boiling it. The ointment was prepared by placing 10% of the extract in Vaseline. (We can send a copy of the article to medical personnel).

Are you in a situation where there is a shortage of antibiotics? This ointment could be prepared for use in the local community anyplace where there is electricity and running water. I would not be surprised if much simpler methods, better suited to preparation as needed in the home, might not also be effective. If you devise and test such preparations, please let ECHO know.

CULTIVATION

Moringa grows best in the hot, semi-arid tropics. It is drought-tolerant and grows with rainfalls of 250-1500 mm (10-60 in) per year. Altitudes below 600 m (2000 ft) are best for the moringa; however, it grows up to 1200 m (4000 ft) in some tropical areas and has been recorded growing at 2000 m (6000 ft). *Moringa stenopetala* in Ethiopia is found at altitudes up to 1800 m (6600 ft) regularly.

At Proyecto Biomasa in Nicaragua, they have found the effective altitude limit for growing moringa is 500 meters. [This might be higher nearer the equator.] Excessively windy conditions will cause the tree to dry out.

In the sub-tropics, moringa will tolerate light frosts. A freeze can kill a mature tree back to the roots as it has our trees here at ECHO, but they are capable of recovering. It quickly sends out new growth from the trunk when cut, or from the ground when frozen. A good temperature range is 25-35° C (77-95° F), although it can take up to 48° C (118 ° F) for limited amounts of time.

The moringa tree prefers well-drained sandy or loam soil. It will tolerate a clay soil but not water logging. At ECHO it is set back when our water table stays for long periods at an inch or two below the surface. It tolerates a wide range of pH (5-9), and grows quite well in alkaline conditions of up to a pH of 9. We have found that it responds well to mulch, water and fertilizer.

Moringa is an extremely fast growing tree. It can reach up to 4 m (15 ft) in a year, reaching an eventual height of 6-15 m (20-50 ft). Roy Danforth in Zaire wrote, "The trees grow more rapidly than papaya, with one three-month old tree reaching 2.4 m (8 ft). I never knew there would be such a tree." The tree in our organic garden grew to about 4 m (15 ft) in 9 months, and had been cut back several times to make it branch out more. It is advisable to prune trees frequently to a shrub form, or they will become lanky and difficult to harvest. If folks begin regularly breaking off tender tips to cook when trees are about 1.3 m (4 or 5 ft) tall, the trees become much bushier.

Those to whom we have sent the tree in Africa have been pleased at its tolerance of dry weather. Rob Van Os rated its growth, yield and potential as exceptional and added that it "can be planted after the other crops, even near the end of the rains." He has introduced it into several villages already. The first plants grew so well for Gary Shepherd in Nepal that he had us arrange for 1,000 of the large seeds. He reports that at five months one was 3.6 m (12 ft) tall and most were 1.8 m (6 ft).

I quote Alicia Ray, who wrote a booklet on the benzolive in Haiti some time ago.

It seems to thrive in impossible places -- even near the sea, in bad soil and dry areas. Seeds sprout readily in one or two weeks. Alternatively one can plant a branch and within a week or two it will have established itself. It is often cut back year after year in fencerows and is not killed. Because of this, in order to keep an abundant supply of leaves, flowers and pods within easy reach, "topping out" is useful. At least once a year one can cut the tree off 3 or 4 feet above the ground. It will readily sprout again and all the valuable products will remain within safe, easy reach.

Beth Mayhood with Grace Mountain Mission in Haiti wanted to establish a model vegetable garden on a small piece of land. "It was windswept and sunbaked with no natural barriers or trees in the area. Soils were poor and very alkaline. The salt content was also high. We started in January to prepare large quantities of compost. In April holes were dug in the poor soil and filled with compost. Benzolive trees planted in seedbeds germinated in 3-4 days. In 9 weeks they were transplanted in between the garden beds, around the edge of the 60 x 75 m (200 x 250 ft) area and in a double row about 1.5 m (5 ft) apart in the middle. The trees protected against the

prevailing winds." I saw slides of this spot later. It was impressive. The light shade of the tree is a considerable help to most vegetables.

I cannot emphasize enough how important it is to use pruning of some sort. If left to itself, the tree becomes quite tall and lanky. This method of cutting it back to 1.2 m (4 ft) each year sounds good. One method I tried with some success was to cut each branch back a foot after it had grown 0.6 m (2 ft) until it was a multibranched shrub. Alternatively, normal harvesting can have the same effect if begun while the tree is young. Beth Mayhood wrote, "We liked them so much we began picking the growing tips to boil as a spinach several times a week. This picking of the growing tips caused the tree to branch. Our constantly pruned trees became thick-limbed and many-branched."

PROPAGATION

Moringa can be grown easily from seeds or cuttings. Seeds should be planted 2 cm or 1 in deep and should germinate within 1-2 weeks. Germination rates are usually very good, but can drop to 0% after two years.

Cuttings 45-100 cm (18-40 in) long, 4-10 cm (2-4 in) wide should be taken from the woody parts of the branches. It should be wood from the previous year. They can be cured for three days in the shade and then planted in a nursery or in the field.

OTHER SPECIES

M. stenopetala is native to Africa and as mentioned earlier, produces larger seeds and leaves than *M. oleifera*. *M. stenopetala* leaves taste similar to *M. oleifera* when cooked and milder if tasted raw. Below is an excerpt on *M. stenopetala* from ECHO's book *Amaranth to Zai Holes* (p. 115).

MORINGA STENOPETALA. *Moringa oleifera*, native to India, is the number one seed in our seedbank, in terms of number of requests and positive reports. When we learned that a moringa native to Ethiopia had larger edible leaves, more drought resistance, and larger seeds (important for those using moringa to purify water), we were obviously interested. Dr. Samia Jahn shared some seed with us in the past, but our supply is very erratic; if you request seed (FOR OVERSEAS NETWORK ONLY), be aware that you may have to wait a while to receive the seed. If this is your first interest in moringa, please do initial trials with *M. oleifera*. If you have had success with *M. oleifera*, it may be time to try this "new" species.

Michael Madany wrote from Somalia of his comparison trial with seed received from elsewhere a few years ago. "In spite of the initial rapid growth of *M. oleifera*, in drier years the species has not done well without some watering. The *M. stenopetala*, by contrast, has the lushest green foliage and continued to grow during the exceptionally long dry season from last August until this April. We began cooking leaves and young shoots in April (taste of the two species very similar). We obviously aren't eating it fast enough, since two large limbs have fallen under their own weight."

Freezes damaged our one *M. stenopetala*, forcing subsequent branching from low on the trunk. Consequently, I have not seen a "normal" mature tree. Dr. Jahn says that in the Sudan *M. oleifera* develops into a slender tree, *M. stenopetala* into a round shrub-like tree. Before the first freeze, however, a few important differences became clear. The trunk is considerably thicker at the base, the tree seems more vigorous, the leaves are larger, and if tasted raw the leaves are milder.

The more bushy M. stenopetala can be planted as a wind break. "Seedlings were planted in a windy corner at a spacing of 1 m. As soon as the upper branches of the tree grew broader, they were cut and the trees responded by more profuse growth of their lower branches, thus thickening the hedge. Vegetables cultivated behind it profited from this protection."

M. stenopetala has been grown as an ornamental in private gardens of Europeans in Kenya, reaching 10-12 meters and their trunk diameter is at least 2-3 times as thick as that of M. oleifera in Sudan. In Ethiopia it is cultivated as high as 1800 meters (5400 feet), where people use ash as the main fertilizer. By the end of a long dry season the trees may have lost their leaves.

ECHO's M. stenopetala tree, over ten years old, has flowered but not yet produced seed. It has been badly damaged by two freezes. Dr. Jahn cites reports that M. stenopetala trees are not as quick to set flowers as M. oleifera. In Sudan the first flowers appeared after 2 1/2 years, compared to 11 months for M. oleifera. Charlie Forst in Haiti reported that his tree flowered in 15 months, grown from a cutting, which may make the difference. In the central plateau of Haiti, the low-branching, large-leafed M. stenopetala has far superior growth in the dry season. It is in full leaf after months without rain, while M. oleifera suffers after severe drought.

Michael Madany wrote again, this time from Kenya. "Since I am quoted in EDN with regard to our experience with Moringa stenopetala in southern Somalia, I'd like to send a few more comments. The last time I saw the trees we planted in February 1986 was January 1990. They had only flowered once (in 1987 or 1988; only a few flowers) and never set seed. Thus, whenever I wanted to plant more, I was obliged to use cuttings. As far as a source of green vegetable matter in the dry season, the tree surpasses its domestic relative Moringa oleifera in that climate (bimodal rainfall of 400-800 mm; 20-40°C). However, for the purpose of producing water-purifying seeds it seems to be not so successful, at least in the first 5 years. I am mystified as to the reasons for this. The provenance for our trees was over 500 km west at a considerably higher elevation." Michael mentions that during the civil war in Somalia the project buildings were destroyed and "all the trees in our garden were cut down."

Jay Ram wrote from the Pacific Neem Mission in Hawaii. "My Moringa stenopetala tree is now 10 feet tall and growing vigorously. I really share your enthusiasm for this wonderful tree. It is one of the best species we have come across. Fast growing with good form, and high palatability. In fact, I commonly will eat the boiled leaves by themselves, [something I do not do with Moringa oleifera which is common on the island]."

There is another interesting difference. The roots of M. oleifera are used as a condiment similar to horseradish. With M. stenopetala it is the bark that is so used.

Dr. Jahn reports on work in the Sudan which shows that optimum light for germination of all moringa species is half shade. When sown in the hotter weather of mid-April, germination percentages for M. stenopetala and M. oleifera were only 54 and 40 percent, compared to 92 and 94 percent in half shade. During the cool dry season there was little difference. Both moringa species can be started from cuttings. However, trees grown from cuttings are known to have much shorter roots. Where longer roots are an advantage for stabilization or access to water, seedlings are clearly preferable.

ECHO does not have a regular source for M. stenopetala. Watch future EDNs for availability, or write to be on our waiting list (send last date we should send seed).

M. peregrina is another moringa species with much potential for oil production. The starchy roots are eaten. This species of moringa has wood that is good for firewood and charcoal and also resists termites.

SEED SOURCES

ECHO can usually provide trial-sized quantities of *Moringa oleifera* to those who are doing agricultural development work. For those seeking other potential sources or large quantities, the following companies sell moringa seed:

- The Banana Tree, 715 Northampton St., Easton, PA, 18042; 610/253-9589; www.banana-tree.com
- Greenleaf Seeds, P.O. Box 98, Conway, MA 01341, USA, p: 413/628-4750 (No telephone orders)
- Carter Seeds, 475 Mar Vista Dr., Vista, Ca, 92083; 760/ 724-5931; www.carterseeds.com
- Hurov's Seeds & Botanicals, P. O. Box 1596, Chula Vista, CA, 91912; , 619/ 690-1741
- Peter B. Dow & Co., P.O. Box 696, Gisborne 3800, New Zealand, fax (079) 78 844
- Ellison Horticultural PTY.Ltd., P.O. Box 365, Nowra, N.S.W. 2541 Australia p: 6144-214255
- Kumar International, Ajitmal 206121, Etawah, Uttar Pradesh, India.
- Shivalik Seeds Corporation, 47, Panditwari, P. O. Prem Nagar, Dehra Dun - 248007, U. P., India; tel. 91-135-683-348; fax 91-135-683-776; E-mail: hilander@del2.vxn1.net.in
- Samuel Ratnam, Inland & Foreign Trading Co., (Block 79A, Indus Road #04-418/420, Singapore, Tel: 0316 p 2722711, fax: 2716118)
- Kenya Forestry Research Institute (KEFRI), P. O. Box 20412, Nairobi, Kenya, Tel. (254) 154-32891; Fax (254) 154-32844; E-mail kefri@arcc.or.ke.
- Tanzania National Tree Seed Programme, P.O. Box 373, Morogoro, Tanzania; Tel: (255)-56-3192 or (255)-56-3903; Fax: (255)-56-3275; E-mail: ntsp@twiga.com; <http://home.twiga.com/ntsp/>

WEB SITES & OTHER INFORMATION

The home page of the family Moringaceae by Mark Olson:

<http://hoya.mobot.org/gradstudents/olson/moringahome.html>

University of Leicester 's Department of Engineering page on moringa:

<http://www.le.ac.uk/engineering/staff/Sutherland/moringa/moringa.htm>

Despite spelling errors this page has good information:

<http://agrss.sherman.hawaii.edu/onfarm/tree/tree0012.html>

Proyecto BIOMASA, Uni Rupap, Costado Sur, Villa Progresso, Managua, Nicaragua:

<http://www.ibw.com.ni/~biomasa/>

ECHO's special web site for moringa

<http://www.moringaseed.com>

Church World Service's web site dedicated to the moringa (and including their book *The Miracle Tree: Natural Nutrition for the Tropics*).

<http://www.moringatrees.org>