ECHO Technical Note

THE MORINGA TREE

By Dr. Martin L. Price

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Moringa oleifera tree. Photo by Beth Doerr

What's Inside

Introduction

The moringa tree, *Moringa oleifera*, has probably been the most popular plant in ECHO's seed bank 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. Of these species, *Moringa oleifera* is the most widely known. In this document, the term 'moringa' refers to *M. oleifera*. All other species are referred to by their Latin name.

17391 Durrance Road, North Fort Myers, FL 33917, USA

Phone: (239) 543-3246 - Fax: (239) 543-5317 - E-mail: echo@echonet.org - Web site: http://www.echonet.org/

USES OF MORINGA

LEAVES

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Fig. 1 Moringa leaves. Photo by Tim Motis

Leaflets (Fig. 1) can be stripped from the feathery, fern-like leaves and used in any spinach recipe. They 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, as they are often 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. ECHO has published a separate Technical Note that includes numerous moringa recipes.

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 best plant foods that can be found." In his book *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.

Researchers at the Asian Vegetable Research and Development Center (AVRDC) showed that leaves of four moringa species (*oleifera*, *peregrina*, *stenopetala* and *drouhardii*) all contained high levels of nutrients and antioxidants. They also found that nutrient content varied little between ten accessions of *Moringa oleifera*. Nutrient content did, however, vary with preparation method, leaf age and harvest season. Though some nutrients in vegetables are lost as a result of cooking, AVRDC scientists observed that boiled moringa leaves or leaf powder provided at least three times more bio-available iron than raw moringa leaves. Boiling also enhanced antioxidant activity of moringa leaves. Nutrient content was higher in mature than young leaves, though people usually prefer to eat young shoots. Vitamin A was highest during the hot-wet season, whereas iron and vitamin C were highest during the cool-dry season.

Experiments at the University of Baroda in India revealed that cooking moringa leaves with oil helps retain beta carotene and enhances the conversion of beta carotene to vitamin A in the body. These studies also showed that, because vitamin A is unstable under acidic conditions, beta carotene is reduced when moringa leaves are cooked with tomato products.

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 many warm-climate countries today, health workers are now treating malnutrition in small children and pregnant and nursing women with moringa leaf powder. The results have often been dramatic and very large numbers of moringa trees are being planted. Some of the results are published below.

An Impressive Moringa Project in Senegal Back to top

Lowell Fuglie with Church World Service (CWS) in Senegal sent us a report on an impressive CWS project called "*Moringa oleifera*: Natural Nutrition for the Tropics" [also adapted and written in ECHO Development Notes (EDN) 64]. ECHO and others have published articles about the many uses, nutritional content and hardiness of this drought-resistant "vegetable tree." Fuglie's 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.

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. Fuglie's report lists the recommended daily allowance (RDA) for the major nutrients for children ages 1-3 and for lactating women and compares these RDAs to the amount of the 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 (same weight as 1/10 of a liter of water) serving of fresh leaves would provide all his daily requirements of calcium, about 75% of his iron and half his protein needs, as well as important supplies of potassium, B complex vitamins, copper and all the essential amino acids. As little as 20 grams of fresh 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 (Fig. 2). Leaves should be dried in the shade to reduce loss of vitamins, especially vitamin A. AVRDC research showed that most nutrients were retained by drying at 50°C (122°F) for 16 hours. The brittle leaves are then pounded and sifted to remove leaf stems. Leaves can also be rubbed over a wire screen to make a powder, which should be stored in a sealed, dark container. The powder can conveniently be added to soups, sauces, porridges, baby food, etc. "It is estimated that only 20-40% of vitamin A content 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."

Fig. 2. Moringa leaves spread out to dry. Photo by Beth Doerr.

"During pregnancy and breast-feeding, women are most at risk of suffering from nutritional deficiencies." Table 1 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 (Fig. 3) with one rounded tablespoon of powder added to his food, three times daily.

Fig. 3. Malnourished child being fed moringa. Photo by Beth Doerr.

Table 1. Percentage of the recommended daily allowance (RDA) of various nutrients supplied to a nursing mother and a 1-3 year old child by moringa leaf powder (6 tablespoons per day for a nursing mother; 1 tablespoon three times per day for a 1-3 year old child).

	RDA (%)	
Nutrition component supplied	Parent	Child
Protein	21	42
Calcium	84	125
Magnesium	54	61
Potassium	22	41
Iron	94	71
Vitamin A	143	272
Vitamin C	9	22

Lowell says he first became aware of the nutritional value of moringa from reading EDN. He did not need to order seeds from our seed bank, however, because moringa already grew wild in Senegal. It was seldom eaten, and Lowell writes, "much of the nutritional content (was) lost by the common practice of boiling the leaves and then discarding the water as many as three times before the leaves (were) eaten." 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, including doctors, nurses, and midwives, in ways of using moringa. Informational booklets, brochures, a seminar and radio spots were put together.

In December 1998, several directors of health- and nutrition-related programs conducted an outside evaluation of the project. The project evaluators interviewed 70 individuals. Based on their report, answers to many of the project's initial questions were obtained. Here are the questions, along with answers based on their report.

Would moringa leaves, leaf powder and pods be visibly 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. "

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." (Fig. 4)

Fig. 4. Pounding moringa leaves to make leaf powder. Photo by Beth Doerr.

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."

Fig. 5 Moringa leaf powder added to food. Photo by Doris Strong.

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 was 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."

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 "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.

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

The Senegal project is written up in a book called *The Miracle Tree: The Multiple Attributes of Moringa,* edited by Lowell Fuglie. The book is available from ECHO Bookstore (echonet.org) in both English and French. A video on the project, made by Lowell Fuglie titled *The Miracle Tree (Moringa oleifera)* is also available from ECHO in English and French.

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.

Fig. 6-7. Moringa trees growing at ECHO (Fig. 6; left) and as a household tree in Africa (Fig. 7; *right*) Photos by Tim Motis (left) and Beth Doerr (right).

Table 2. Nutritional value of *Moringa oleifera*.* Moringa pods, fresh (raw) leaves and dried leaf powder have shown them to contain the following per 100 grams of edible portion:

Component analyzed	Pods	Leaves	Leaf Powder
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	1600
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 (mg)	90	402	1325
Histidine (mg)	27.5	141	613
Lysine (mg)	37.5	288	1325
Tryptophan (mg)	20	127	425
Phenylanaline (mg)	108	429	1388
Methionine (mg)	35	134	350
Threonine (mg)	98	328	1188
Leucine (mg)	163	623	1950
Isoleucine (mg)	110	422	825
Valine (mg)	135	476	1063

* From *The Miracle Tree:* Edited 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, particularly with what efficiency they are converted to retinol, and how much is lost or inactivated due to various moringa-processing methods.

Moringa Research by BIOMASA

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At Proyecto BIOMASA, an agricultural research program located in Nicaragua, moringa has been studied for over six years. Researchers have found evidence, for example, that moringa can be used as a foliar spray to increase plant growth and as a green manure to improve soil fertility. Lowell Fuglie summarized some of BIOMASA's major findings in a report excerpted below.

1) BIOMASA has discovered that **moringa leaf extract contains a plant growth hormone**. Fuglie writes, "Juice from fresh moringa leaves can be used to produce an effective [spray containing] 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 cytokinins 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 hormone [spray] increased maize yields from 60 to 130 sacks per hectare. Using this hormone [spray], BIOMASA was able to grow coffee at 30 meters altitude. Coffee, shaded with *Jatropha curcas*, produced beans in just 17 months."

Fuglie describes how the spray was made at BIOMASA:

"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 [from] the moment plants emerge, again at about 30 days before plants begin to flower, again when seed appears and again during the maturation phase."

2) **Moringa shoots can also be used as a green manure**. Fuglie writes, "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 seeds per hectare. The density can be greater: the only limits to plant density are availability of seed, water and fertilizer). After 25 days, plow the seedlings into the soil to a depth of 15 cm. Prepare the land again for the crop desired.

"Seeding can be done mechanically if the seeds are first de-hulled (see page 9 for information about how Nikolaus Foidl at BIOMASA de-hulls moringa seed and Appendix A on page 16 for diagrams of a de-huller from Church World Service). 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."

3) "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.

"The green matter is harvested when plants reach a height of 50 cm or more (every 35-40 days). To harvest, 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.]

4) BIOMASA conducted extensive trials using **moringa leaves as livestock feed** for beef and milk cows, swine, and poultry. When moringa leaves constituted 40-50% of feed, milk yields for dairy cows and daily weight gains for beef cattle increased 30%. "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." Milk production was 10 liters/day when cows were fed moringa, compared to 7 liters/day without moringa. With moringa feed, daily weight gain of beef cattle was 1,200 grams/day, compared to 900 grams/day without moringa feed."

Fuglie makes some comments in his report: "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 (Table 3):

Table 3. Highest amount (%) of protein and fiber in livestock feed considered safe for cows and pigs.

Animal	Protein	Fiber
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)." Foidl explains that ruminants need nitrogen to feed the bacteria in their stomach, but too much nitrogen can lead to reduced liver and kidney function and possibly to death.
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"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; they are already equipped with the enzyme that enables them to break down food material. [Phytase feed enzyme products are sold through worldwide distributors of companies such as BASF (Natuphos), Danisco (Phyzyme™), DSM Nutritional Products (Ronozyme® or Roxazyme®) and JBS United (Optiphos®). Formulations and prices of these products vary.]

With moringa as 40-50% of feed, "the average birth weight for local Jersey cattle, usually 22 kg, increased by 3-5 kg. "The higher birth weight 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.

5) Sometimes **moringa leaf concentrate** is preferable to fresh leaves for use in livestock feed. "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." The protein can be freeze-dried after the liquid has been poured off.

Nikolaus Fiodl of BIOMASA wrote to us about a somewhat simpler alternative to freeze-drying. He wrote, "Take a pressure cooker and fit a copper or steel tube in the top. Take a compressor from an old refrigerator. Link the tube to the compressor inlet and run the compressor. At a temperature of 30 degrees C and about 50 mm of vacuum you can take out most of the water by evaporation in vacuum.

"If you wish to use the concentrate 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, the homemade pellets can be mixed with the normal fodder. Foidl warns, "Be careful not to overdo it with protein; fattening pigs need 12-14% protein and lactating pigs need 16-18%."

PODS

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The young pods (Fig. 8), 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.

Figs. 8-9. Moringa oleifera seed pods (Fig. 8; left) and flowers (Fig. 9; lower right). Photos by Tim Motis

FLOWERS

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After 8 to 12 months, the tree begins to flower and continues year round. The flowers (Fig. 9) 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 calcium and potassium. Moringa flowers also provide a year-round source of nectar for bees, although some have claimed that honeybees do not gather nectar from moringa.

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Seeds (Fig. 10) can be extracted and eaten as "peas" (boiled or fried) when still green. The dry seeds are apparently not used for human consumption, perhaps because the bitter coating becomes hardened.

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 and perfumes and has been used as a watch lubrication, but was replaced long ago by sperm oil. It can be used for making soap and is also excellent to burn for light. The oil is slow to become rancid. The species, *M. peregrina*, from the Red Sea area reportedly produces very good oil.

Fig10. Seeds of Moringa oleifera (brown seeds on left) and Moringa stenopetala (larger, white seeds on right). Photo by ECHO staff.

Oil can be extracted from moringa seed in the home. Seed from mature pods-which can be 60 cm (24 in) long-are roasted, mashed and placed in boiling water for 5 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 liters of oil from 11 kg of kernels. Once the best processing conditions are worked out, an extraction efficiency of 65% could probably be expected."

BIOMASA also researched moringa seed oil extraction. Fuglie states in his report, "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).

Foidl suggests that a screw press made of simple iron may be better suited for moringa oil extraction than one made of steel. Chromium and nickel in steel may react with the oil at high temperatures and lower oil quality. One possible screw press 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 will process 80-90 kg/hour. [Contact FAKT - FAKT Consult for Management, Training and Technologies, Gänsheidestrasse 43, 70184 Stuttgart, Germany; phone: + 49 (0) 711 21095-0; fax: + 49 (0) 711 21095-55; website: http://www.fakt-consult.de; e-mail: fakt@fakt-consult.de]

Fuglie continues, "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 tocopheral acetate (vitamin E). A few (1-5) drops per liter of the essential oil of sage, rosemary or mint (or a twig of the latter), [all]

excellent antioxidants, 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.)"

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 (see below). It is being researched as an animal feed, but has a bitter taste and contains anti-nutritional factors (glucosinolates, haemagglutinins, alkaloids and a saponin). We have read that in order to remove the bitter taste and anti-nutritional factors, you can soak the seedcake in water for 20 to 30 minutes, then sieve it to recover the residue. We do not know of feeding trials that were done in the field to test this method.

In addition to their usefulness as a source of oil, **moringa seeds can be used for water treatment** (Fig. 11)**.** Dr. Samia Jahn, a German woman who for many years worked for the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), told ECHO how to use moringa seeds to clarify water. Suspensions of ground seed of the moringa 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 will also remove a good portion of the suspended bacteria. Jahn wrote that river water is always polluted with human waste. At GTZ's sampling site, the total coliform bacteria count during the flood season was 1,600-18,000 per 100 ml. After one hour of treatment with moringa seed powder, the coliform count was 1-200 per 100 ml. According to Jahn, "Good clarification is obtained if a small cloth bag filled with the powdered seeds of the moringa is swirled round in the turbid water."

Fig 11. A comparison of non-treated (jar on left) vs. moringa-seed-treated (jar on right) pond water. Photo by Beth Doerr.

To prepare the seed for use as a coagulant, remove the seed coats including the "wings." The white kernel is then crushed to a powder using a mortar or by 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 cup of clean water in a bottle (e.g. a soda 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 20 liters of 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).

BIOMASA also studied moringa seed powder for use in water treatment. From Fuglie's report: "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."

A SPECIAL NOTE: 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."

Fuglie claims that a general rule of thumb is to use powder from one moringa kernel for 2 liters of water when water is slightly turbid, and powder from one kernel for 1 liter when water is very turbid. The seeds and powder can be stored, but the paste (mentioned a few paragraphs previously) needs to be fresh for purifying the water.

Fuglie states that according to BIOMASA, "Seed powder can also be used to harvest algae from waste water, currently an expensive process using centrifuges." Spirolina algae is used in health food and cosmetic products, and it is a common fish food ingredient. The algae is farmed in Mexico and Israel with minor production in other countries. To harvest the algae, sprinkle seed powder on the water. "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." Be aware that algae food or feed products can contain toxins from the water in which the algae was grown.

100% of the protein in fish food can come from algae sources, but at most 10% of protein in cattle feed can be replaced with algae protein. Foidl comments that algae protein has a different composition of amino acids than other proteins. Mammals' main source of protein should be from plants or animals.

WOOD

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Moringa wood is very soft. It is advocated by some as a good live fence tree. This may be true if it is used as living fence posts with wire or other material attached to the tree. At ECHO we attempted to make an animal-proof fence using extremely close spacing between trees, but we were not successful. Trees were spindly and would not restrain anything. Moringa makes acceptable firewood but poor charcoal. According to Foidl, moringa wood makes excellent paper 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

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Small trees a few months old can be pulled up and the taproot (Fig. 12) can be ground, mixed with vinegar and salt and used in place of horseradish. We are 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 several alkaloids including the toxic and physiologically active moringinine. Eating large amounts of the root at once or too often should be avoided, because roots also contain pterygospermin (see below) and an alkaloid called spirachin, a nerve-paralyzing agent.

Fig 12. Root of a young moringa tree. Photo by Tim Motis

USE AS AN ANTIBIOTIC

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Pterygospermin and/or related compounds (isothiocyanates), found in various parts of the moringa plant, have been shown to have antibiotic and fungicidal properties. Though other moringa plant parts are reported to be effective against infections, much of the formal research to date has focused on extracts from the seed. A study at the University of San Carlos in Guatemala was summarized in *EDN* 37 (*Amaranth to Zai Holes* p. 298); a reprint of the summary follows:

"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 (0.02 lb) powdered moringa seeds in 100 ml (3.4 oz) of 45°C (96°F) water for 2 hours. The part that is a bit more complicated is reducing the 100 ml (3.4 oz) down to 10 ml (0.34 oz) 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)."

Further studies were done in 2001 by researchers in the biology department at Gordon College in Wenham, Massachusetts. Jennifer Bonina, Grace Ju and Russell Camp wanted to develop a method of extraction that did not require specialized equipment or rotoevaporation. They ground *Moringa* seeds with a mortar and pestle, then placed the powder in 90ºC (194°F) water for 1 hour with some shaking. The extract was filtered through coffee filter paper, and the liquid was used to saturate small filter disks. The disks were placed on bacteria growing on nutrient medium. The seed extract inhibited growth of *S. aureus* and *B. subtilus*, but did not inhibit growth of *P. aeruginosa* and *E. coli*. The filter paper and flasks were sterilized for the experiment.

If you are in a situation where there is a shortage of antibiotics but you have access to electricity and running water, perhaps this ointment could be prepared for use in the local community. If you make and test ointment from moringa seeds, please let ECHO know.

CULTIVATION

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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). *M. stenopetala* in Ethiopia is regularly found at altitudes up to 1800 m (6600 ft). At Proyecto Biomasa in Nicaragua, they found the effective altitude limit for growing moringa to be 500 m (1640 ft). [This might be higher nearer the equator.] They also say that excessively windy conditions cause the tree to dry out.

Fig 13. Intensive moringa cultivation in northern Senegal.
Photo by Caroline Olivier, Church World Service.

In the sub-tropics, moringa will tolerate light frosts. A freeze can kill a mature tree back to the roots (as has happened to our trees here at ECHO), but it is capable of recovering. It quickly sends out new growth from the trunk when cut, or from the ground when frozen. A good temperature range for the tree is 25-35º C (77-95º F), although it can tolerate up to 48ºC (118ºF) 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 the tree 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), growing quite well in alkaline conditions 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 seeds to be shipped. He reports that at five months one was 3.6 m (12 ft) tall and most were 1.8 m (6 ft).

Alicia Ray wrote a booklet on the moringa (or benzolive) tree in Haiti some time ago. She wrote, "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 sun baked 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. Moringa 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, and 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 (Fig. 14). 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 multi-branched shrub. It appears that there is genetic variability that results in some trees that are pruned sending the new branches straight up rather than to the sides. ECHO planted seed from every source in our seed bank looking for trees that have horizontal branching in response to pruning. The Indian variety PKM-2 seems to do best. This also makes it a better shade tree. 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."

Fig 14. Regrowth after cutting back to about 1.2 m (4 ft). Photo by Tim Motis

PROPAGATION

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Moringa can be grown easily from seeds or cuttings. Seeds should be planted 2 cm (approximately 1 in) deep and ought to germinate within 1-2 weeks. Germination rates are usually very good, but can drop to 0% after 2 years. Dr. Jahn reports on work in the Sudan that 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 *M. oleifera* and *M. stenopetala* (described in the following section) can be started from cuttings. Cuttings 45-100 cm (18-40 in) long with stems 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. Cuttings can be cured for three days in the shade and then planted in a nursery or in the field. However, you should note that 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.

OTHER SPECIES

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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 adapted 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 seed bank 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 which we shared with our network. The trees (Fig. 15) at ECHO have flowered but never produced seed. Occasionally are able to get seed from those to whom ECHO has sent seed. If you have had success with *M. oleifera*, it may be time to try this "new" species. The genetic base is probably quite limited because all the trees came from a small number of original seeds. So if *M. stenopetala* does well, you might want to try to find a second source to increase the diversity in the genetic base before beginning a large project.

Fig 15. A Moringa stenopetala tree at ECHO (Florida). Photo by Tim Motis

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."

Compared with *M. oleifera*, the trunk of *M. stenopetala* is considerably thicker at the base, the tree seems more vigorous, the leaves are larger, and if tasted raw the leaves are milder (Fig. 16). Dr. Jahn says that in the Sudan *M. oleifera* develops into a slender tree, *M. stenopetala* into a round shrub-like tree.

Fig 16. Trunk and leaves of Moringa stenopetala. Photo by Tim Motis

The more bushy *M. stenopetala* can be planted as a wind break. We were told of one situation as follows: "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 trees have been grown as ornamentals in private gardens of Europeans in Kenya, reaching 10-12 meters. Their trunk diameters are at least 2-3 times as thick as that of *M. oleifera* in Sudan. In Ethiopia, *M stenopetala* 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.

Dr. Jahn cites reports that *M. stenopetala* trees are not as quick to set flowers (Fig. 17) as *M. oleifera*. In Sudan the first flowers appeared after 2 1/2 years, compared to 11 months for *M. oleifera*. Charlie Forst reported that a tree that he planted in the Central Plateau of Haiti flowered in 15 months; however, it was grown from a cutting, which may make the difference. At that site, the low-branching, large-leafed *M. stenopetala* showed far superior growth in the dry season. It is in full leaf after months without rain, while *M. oleifera* suffers after severe drought.

Figs 17-18. Flowers (left; Fig. 17) and pods (right; Fig. 18) of Moringa stenopetala in Haiti. Photos by Tim Motis

Michael Madany wrote again, this time from Kenya. "Since I am quoted in EDN with regard to our experience with *M. 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 *M. 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 *M. 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 *M. 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.

A Caution about Eating Excessive Amounts of *Moringa stenopetala*: Eat Like the Deer
Excerpt from EDN Issue 82, January 2004, By Dawn Berkelaar:

The East African Medical Journal featured results of a survey involving 597 school children and their parents in areas of southern Ethiopia with very high incidence of goiter. Measurements of iodine concentration in the urine showed that children were getting plenty of iodine (lack of iodine can cause goiter). One important factor in the prevalence of goiter was a familial tendency to develop goiter. Children whose parent(s) had goiter were significantly more likely to develop goiter themselves.

Also significant was the role of locally consumed foods. Survey participants were questioned about the regions' most commonly consumed foods, including maize, yam, potato, teff, *M. stenopetala* (locally referred to as halleko) and sorghum. Only *M. stenopetala* had a significant association with the prevalence of goiter. In particular, those who ate *M. stenopetala* more than twice per day were 4.57 times more likely to have goiter than the other groups.

The authors of the article mentioned that isothiocyanate and hydrocyanic acid have been isolated from *M. pterygosperma*, now thought to be *M. oleifera*. Isothiocyanate is a known cause of goiter, while hydrocyanic acid metabolizes to thiocyanate in the human body. *M. stenopetala* may have similar substances.

The authors recommend that further studies be done on *M. stenopetala* to find out what links (if any) its consumption has to the occurrence of goiter. Until then, what should you do if you are growing *M. stenopetala*? Before you become alarmed and stop eating the leaves of this valuable tree, remember that practically any food contains both helpful compounds (e.g. carbohydrates for energy; protein; vitamins and minerals) and harmful ones (e.g. hydrocyanic acid). Our advice has been stated in EDN many times previously: "Eat like the deer." That is to say, whenever possible, eat a variety of different foods in moderation rather than very large quantities of one thing.

MORINGA PEREGRINA. Native to the Red Sea area, *M. peregrina* is another moringa species with much potential for oil production. The starchy roots are eaten. The leaves were found by AVRDC researchers to contain more antioxidants than three other moringa species (*oleifera*, *stenopetala*, and *drouhardii*), though antioxidants were high for all four of the species tested. The wood of *M. peregrina* resists termites and is good for firewood and charcoal. As the tree ages, its leaves become longer with smaller leaflets (Fig. 19).

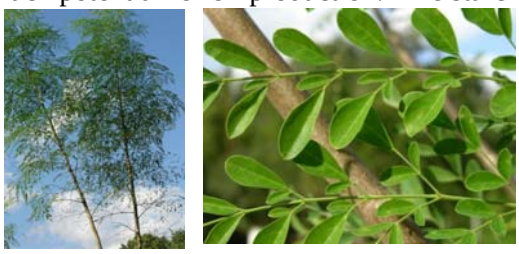

Fig 19. A tree and narrow leaflets of M. perigrina. Photos by Tim Motis

SEED SOURCES

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ECHO can provide trial-sized quantities of *Moringa oleifera* at no charge to those who are doing agricultural development work. For others or those seeking larger quantities, write us for prices. The following companies indicate that they sell moringa seed:

- The Banana Tree, 715 Northampton St., Easton, PA, 18042; 610/253-9589; http://www.banana-tree.com/
- Carter Seeds, 1611-A SO Melrose Dr. #1, Vista, CA, 92083; 800/872-7711; http://www.carterseeds.com
- Hurov's Seeds & Botanicals, P. O. Box 1596, Chula Vista, CA, 91912; , 619/ 690-1741
- Ellison Horticultural PTY.Ltd267 Rous Road, A/stonville NSW 2477 Australia p: 6144-214255

- Horti Nursery (for bulk orders), 25 1st Fl. Raji Medical Bldgs, 1103 EVN Rd. ERODE, 638009, TN INDIA; p:91-424-261815; fax: 91-424-267588;e-mail: kodis@eth.net

- 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.vxnl.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

WEB SITES WITH MORE INFORMATION

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- Moringa News network of people interested in Moringa and clearinghouse for Moringa information: http://www.moringanews.org/

- Trees for Life Moringa information: http://www.treesforlife.org/project/moringa/default.en.asp

- Miracle Tree book by Church World Service: http://www.moringatrees.org/

- University of Leicester 's Department of Engineering page on moringa: http://www.le.ac.uk/engineering/staff/Sutherland/moringa/moringa.htm

- The home page of the family Moringaceae by Mark Olson: http://www.mobot.org/gradstudents/olson/moringahome.html

- Phytochemical and Ethobotanical database: http://www.ars-grin.gov:8080/npgspub/xsql/duke/plantdisp.xsql?taxon=1435

- PDF document on Moringa by HDRA: http://www.hdra.org.uk/pdfs/international_programme/Moringa.pdf

- PDF document on growing Moringa by AVRDC: http://www.avrdc.org/LC/indigenous/moringa.pdf

- ECHO's web site contains information about Moringa and our bookstore has several Moringa publications: http://www.echonet.org

APPENDIX A

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A Seed Dehusker from Church World Service

Church World Service's booklet "Design for a Hydraulic Press Adapted for Moringa Seeds" says the following about the pictured seed dehusker:

"A simple machine can be built to make the job of removing the shells easier. This pedal-powered seed dehusker was built by a Senegalese technician in Dakar.

"Although a fan was built into the machine for the purpose of separating the chaff from the kernals, this proved to be impractical and the fan is presently not being used.

"Inside the machine, a turning screw shaft cracks the shells and the whole kernels and bits of shell drop through the hole at the bottom. The space between the end of the shaft and the machine housing can be adjusted to accommodate different types of seed."