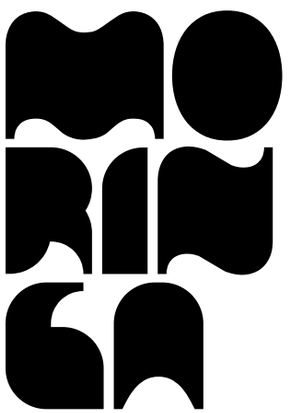
Growing and processing moringa leaves

Moringanews / Moringa Association of Ghana



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INTRODUCTION

The story of moringa

Within the past ten years, ***Moringa oleifera***, a tropical, multipurpose tree has grown from being practically unknown, even unheard of, to being a new and promising nutritional and economic resource for developing countries. The leaves, which are easy to grow and rich in proteins, vitamins and minerals, are becoming widely used in projects fighting against malnutrition. Producing moringa leaves is also a means of generating agricultural income, developing the food processing industry and founding new businesses.

Native to India, the moringa tree grows widely in Africa, where, up until recently, it was used solely around houses to form hedges or to give shade. Occasionally it was used for medicinal purposes or collected for food. The Haussa from Niger and Nigeria, who eat the moringa leaves as a vegetable, are the only ones who have been, for decades now, growing and selling this product.

At the end of the 1980s, when moringa was being studied by a few researchers, uniquely for its water-treatment properties[1], I "discovered" moringa leaf farming in Niger and how profitable it was. A fieldtrip in India allowed me to further my knowledge alongside agronomists and farmers involved in moringa fruit production[2]. Those observations and the South-South exchanges that followed were very helpful in developing moringa leaf farming in Africa.

During the 90s, researchers, businesses and NGOs helped further develop moringa agronomics, the use of its leaves in food and its seeds in oil production or water treatment.

In 2001, I organised an international conference in Tanzania to help foster a network of people most involved in developing moringa as well as to assess what knowledge and know-how had been established. As an outcome, the Moringanews network and website were created.

In 2006, in Ghana, I brought together, for a second conference, around one hundred organisations and businesses working on the moringa leaf. These international conferences and the Moringanews website have heavily contributed to developing the knowledge and the uses of moringa.

At the same time, American NGOs such as the Church World Service in Senegal and ECHO in Mauritania promoted the use of moringa leaf powder. The nutritional values of moringa powder are highly concentrated. A few grams a day can help fight against vitamin, mineral and protein deficiencies. For these projects, moringa leaf powder was used exclusively for a specific population and was well monitored, having a clearly positive impact on the health of those who took it.

1 Moringa seeds contain a protein that can be used to clarify water: it is a natural flocculent.
2 In India, the green Moringa fruit is popularly eaten and sold as a vegetable.

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Then knowledge spread about moringa and encouraged numerous parties, NGOs, small businesses, farmers and individuals, to produce leaf powder and market it, without necessarily ensuring quality standards. These standards cannot be overlooked as the consumption of moringa leaf powder by vulnerable populations such as pregnant women, very young children, the elderly or HIV positive people poses ethical problems.

Leaf powder, if of poor sanitary quality, can cause digestive illnesses. Counterfeit products (various mixtures of dried leaves, even ground twigs) are also an issue in certain countries. Packaging also has an impact on quality: moringa leaf powder, packaged in transparent bags, sold on stands in the sun, rapidly loses its most essential vitamins. This raised local authorities' concern, and rightly so, about the quality of this new product as well as its uses.

The Ghanaians were the first ones to be aware of the need to regulate the moringa leaf powder trade. The Moringa Association of Ghana (MAG) contacted the Ghana Standard Board and the Ghana Food and Drug Board to devise quality control procedures. Moringanews and the MAG collaborated to submit a project proposal to the Centre for the Development of Enterprise (CDE) in Brussels. This guide is one of the outcomes of the ambitious project. The Ghana Standard Board published the moringa leaf powder standards as well as a Good Practices Guide and an Inspection Guide. These standards will most likely be applied in other countries and even become used Africa-wide.

The manual that you are holding, **elaborated by Moringanews and the MAG with the financial support of the CDE and the CTA** (Technical Centre for Agricultural and Rural Cooperation), hopes to enable various parties: farmers, organisations, NGOs, entrepreneurs etc. to attain these quality standards by practicing simple production, processing and packaging methods.

1 Armelle de Saint Sauveur with her guests at the Moringa Seminar in Accra.
2 Mélanie Broin and Vanisha Nambiar at the Moringa Seminar in Accra.

Precise information about average nutritional values in fresh or dried moringa leaves can be found at the end of the guide. The impact that cooking methods have on the vitamins as well as the solubility of these vitamins in water and oil are also discussed. This information is included to help vendors and consumers make the best choices about how to dose and prepare moringa leaves.

This guidebook does not intend to impose limitations on the uses of local plants with excessive regulations, but conversely to develop and diversify them. With the publication of the standards and good practices, moringa leaf powder will be able to access the formal economy. People can thus purchase it worry-free and agro-food businesses can use it to enrich their products. It can hence benefit a wide population who buy local products which are inexpensive but often lacking in proteins, vitamins and minerals.

The purpose of this guide is to develop quality moringa leaf production and consumption. This leafy vegetable is an exceptional resource for developing countries. **Processed or fresh, the moringa leaf is not only a new, promising source of income and employment, but also an outstanding, nutritionally rich vegetable for families and businesses.**

Armelle de Saint Sauveur
January 2010

An adult *Moringa oleifera*.

1. The moringa plant

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The moringa plant (*Moringa oleifera*) is known worldwide for its nutritional and medicinal benefits and industrial uses (Tables 1&2). Almost every part of the moringa plant has nutritional value. The pod is cooked as a vegetable in India and exported to many countries for Indian expatriates, fresh or canned. The root can be used as substitute for horseradish. Foliage is eaten as greens, boiled, fried, in soups or for seasoning. Dried leaf powder can be added to any kind of meal as a nutritional supplement. The seed can be roasted and eaten like a peanut.

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1 A moringa plantation.
2 Fruits and leaves.
3 Flowers and leaves.
4 Seeds, leaves and leaf powder.

The seeds can be used as a flocculent to clarify water and as a source of a non-drying and very stable oil, known as Ben oil. This oil, which was once used for lubricating watches and other delicate machinery, is clear, sweet and odourless, almost never going rancid. It is edible and it is becoming increasingly popular in the cosmetics industry. Leaves and young branches are used as fodder. Moringa may also be used in fish and poultry feeds. The bark yields a blue dye and can also be used in tanning. The wood can produce paper. A plant growth hormone can be extracted from young shoots, which when applied as a foliar spray, increases yields dramatically in almost any plant. Last but not least, almost every part of the plant has pharmacological properties.

Table 1
Plant parts and their benefits.

Tree Part	Uses or benefits
Leaves	Nutritional, forage, biomass, plant growth hormone, medicinal
Flowers	Nutritional, medicinal, honey
Fruit	Nutritional, medicinal
Roots	Medicinal
Seed	Cosmetics, food, water treatment, medicinal
Wood	Paper, alcohol production, animal feed, medicinal
Bark	Rope making, gum for tanning hides, medicinal

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1 Moringa-based food and cosmetic products.
2 Moringa leaf powder for sale in Ghana.

Table 2
Some useful ingredients in parts of the moringa.

Ingredient	Tree Part
Lignin/cellulose	Stems
Alcohol	Stems
Hormones	Leaves
Bioflavanoid	Leaves, flowers and stems
Arachidic acid	Seed and leaves
Oleic acid	Seed and leaves
Linoleic acid	Seed and leaves
Linolenic acid	Seed
Pterygospermin	Flowers

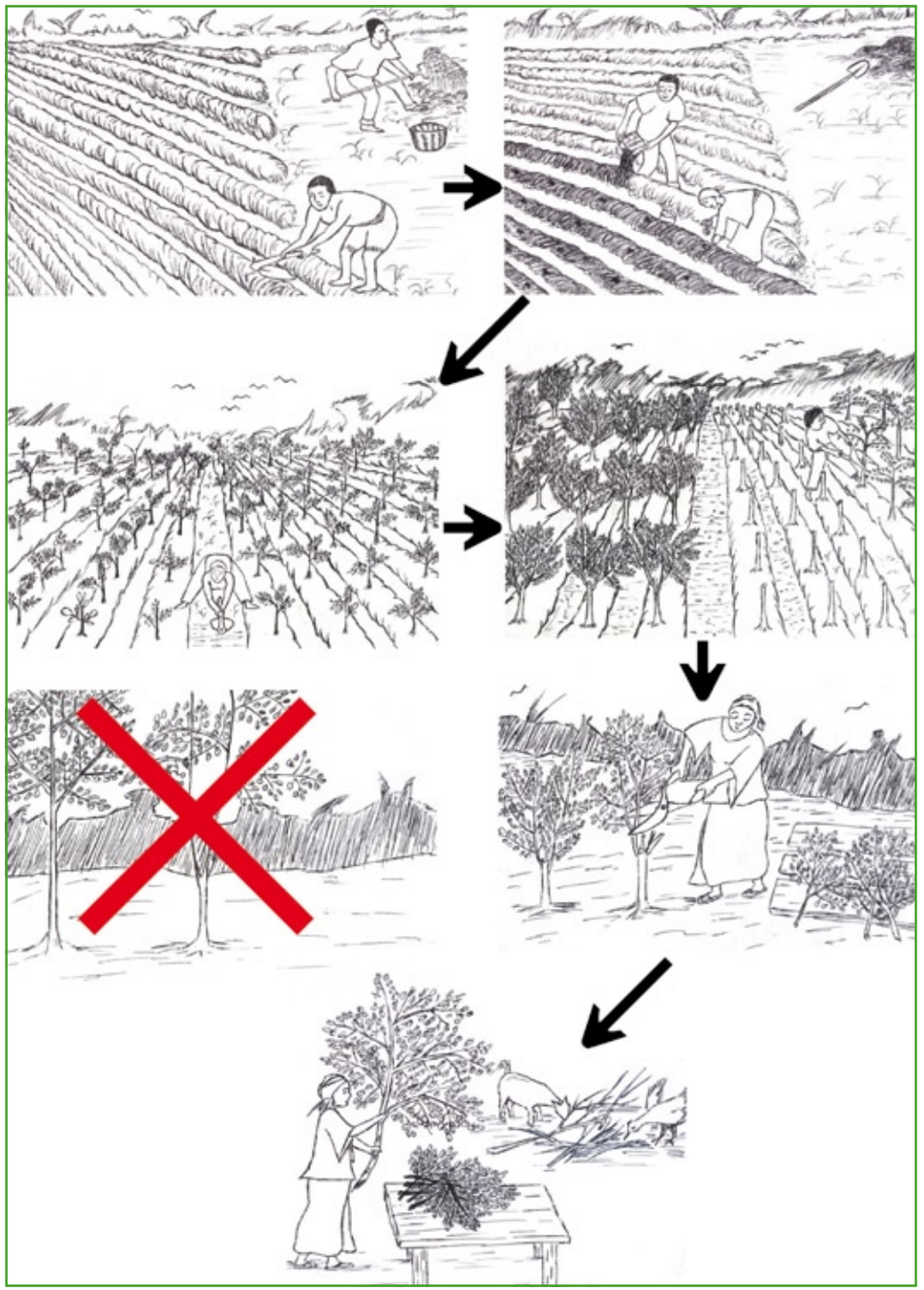
2. The need for a manual

Since commercial utilization of moringa is now being introduced, the Moringa Association of Ghana (MAG) sees the need to ensure that all parties with an interest in the plant are properly informed and instructed about the various stages of its production. By using this manual, a farmer or processor will have all the necessary information to ensure that the end product meets all safety and environmental criteria.

3. The scope of the manual

The purpose of this document is to provide an easy-to-follow set of practices to ensure that moringa products comply with all safety and environmental requirements. The practices recommended here will help to promote good farming and manufacturing methods to obtain healthy trees and quality-processed products. This guide addresses the topics of cultivation, harvesting, transportation, processing, packaging and storage as well as the various ways of using moringa.

CULTIVATION



Growing moringa leaves.

To ensure top results and benefits, the following four steps are fundamental in moringa cultivation:

- Site selection
- Land preparation
- Planting/sowing
- Maintenance of the plantation

1. Site selection

Environmental requirements for the moringa plant are shown in the following table.

Table 3
Environmental requirements for moringa.

Parameter	Requirement/Range
Climate	Tropical or sub-tropical
Altitude/Height	0-2000 meters
Temperature	25-35°C
Rainfall	250mm-2000mm. Irrigation needed for leaf production if rainfall < 800mm
Soil Type	Loamy, sandy or sandy-loam
Soil pH	Slightly acidic to slightly alkaline (pH 5-9)

Choose an area where the soil is well drained. This helps to evacuate excess water from the soil and allows a free exchange of gasses between the atmosphere and soil particles. Avoid clay soils that become sticky when wet and very hard when dry. Avoid termite-infested soils as much as possible. It should be an open area to receive full sunlight. The site must be protected from free roaming animals by an adequate natural or artificial fence.

The following sites are not recommended for moringa cultivation.

Table 4
Undesirable sites for moringa cultivation.

Site	Reason(s)
Industrial waste dumps	Absorption of undesirable or toxic heavy metals e.g. mercury, arsenic, lead, etc.
Refuse dumps	Absorption of undesirable or toxic heavy metals e.g. mercury, arsenic, lead, etc.
Water logged sites	Poor drainage causes roots to rot. e.g. rice fields, clay, river beds, etc.
Termite infested soils	Destruction of young and mature trees
Animal grazing fields	Destruction of young and mature trees

2. Soil/land preparation

The ease with which the roots spread is a necessary condition in plant growth and development. Moringa therefore requires a well-drained loamy or sandy soil for optimal growth.

The land should be slashed where necessary and all unwanted materials removed from the field. If planting density is high, the land must be ploughed and harrowed to a maximum depth of 30 cm. If planting density is low (>1 m x 1 m), it is better to dig pits and refill them with the soil. This ensures good root system penetration without causing too much land erosion (ploughing can be risky in some tropical environments, in the cases of heavy rains, wind or sloping). In this case, the pits must be 30 to 50 cm deep, and 20 to 40 cm wide. When refilling the pit, mix the soil with manure.

For the farmer producing moringa on a large scale it is recommended that soil and seed testing are done to ensure good returns on investment.

3. Propagation

Moringa can be propagated from seeds or from mature cuttings (brown wood).

Seed propagation

Purchase or collect your supply of seeds from reliable sources. A good seed should be viable, clean and disease free. Seeds should not be stored over long periods as they lose viability (germination capacity) after about one year. There are around 4000 moringa seeds (with their shell) in a kilo.

Seeds may be sown in containers, in seedbeds or directly in the field.

Direct seeding is preferable when the germination rate is high, which is the case with *Moringa oleifera*. In Togo for instance, in small holders' farms, the germination rate is more than 85% only 12 days after seeding.

Production in seedbeds has the following drawbacks:

- It requires more work, especially when transplanting
- Transplanting can damage the taproot: fragile and essential in ensuring the future yield and the drought resistance of the plant

Production in containers has the following drawbacks:

- It is very time consuming: filling and placing the bags, maintenance, transport and transplanting
- It is expensive in manpower and material

Direct seeding

Seeds must be sown at a maximum depth of 2 cm. Deeper seeding will greatly reduce the germination rate. One or two seeds per pit can be sown. When seeds are expensive or difficult to acquire, a better option is to plant one seed only and to wait two weeks for germination to occur. Then, the empty spaces are refilled. When the seed quality is more uncertain or the seeding period not optimal, use two seeds per pit.

If the two seeds germinate, the weaker plant can be removed after they reach about 30 cm. This must be done carefully to avoid damaging the root system of the remaining plant. Transplanting seedlings produced by direct seeding is not advised, as there is a high risk of damaging the taproot.

Moringa seeds germinate 5 to 12 days after seeding. If the seed has not germinated after two weeks, it will not and must be replaced. If neither of the two seeds germinate, the pit must be opened to check if there is a localized insect attack (ants or termites). If this is the case, the pit must be treated with a neem leaf solution or, better yet, with neem oil mixed with soapy water. Then seeding can be done again.

Propagation in containers

Suitable containers are polyethylene bags or sacks prefilled with damp loamy soil popularly known in Ghana as "Top soil". Sowing depth should be no more than 2 cm. Seeds should germinate within 5-12 days after sowing.

Place the bag(s) in a slightly shaded area and where they are protected from heavy rains. If this is not possible, make a set of small incisions (2-3) on the polybag to serve as drains to avoid water logging. Water the seed every 2 to 3 days depending on the dampness of the soil, 10-20 ml of water applied to each bag is recommended. At this stage the young shoot or plant must be well protected from grasshoppers, locusts, termites and ruminants.

Watering must be done with extreme care to avoid collapse of the feeble plant due to pressure. Collapsed plants must be suitably supported. The young moringa plants must be nursed for 4-6 weeks before transplanting, when they are about 30 cm high. Remove the polythene bag when transplanting ensuring that the roots of the plant are not damaged.

Propagation by cuttings

Hard woodcuttings of one meter long and at least 4 to 5 cm in diameter can also be used for propagation. When planted, one third of the stem must be buried in the soil. Plants produced with cuttings will not have a deep root system and will be more sensitive to wind and drought. Cuttings are also more sensitive to termite attacks.

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1 Cuttings before planting.
2 Cuttings starting to sprout.

4. Planting

For leaf production, several options can be considered.

Intensive production

The spacing of plants should be 15 x 15 cm or 20 x 10 cm, with conveniently spaced alleys (for example: every 4 meters) to facilitate plantation management and harvests. Another option is to space the seeding lines 45 cm apart and to sow every 5cm on those lines. One can also space the lines only 30 cm apart and sow at a larger distance on the lines (10 to 20 cm). These intensive systems are appropriate for commercial production but require careful management. Weeding, manuring and disease prevention require more skill because of the high density.

Semi-intensive production

Plants are spaced 50 cm to 1 m apart. This is more appropriate for small-scale farmers and gives good results with less maintenance.

Agroforestry

Moringa trees can be sown in alleys and associated with other crops. The distance between moringa rows must be 2 to 4 meters, and they must be oriented East-West to ensure that intercrops receive enough sun.

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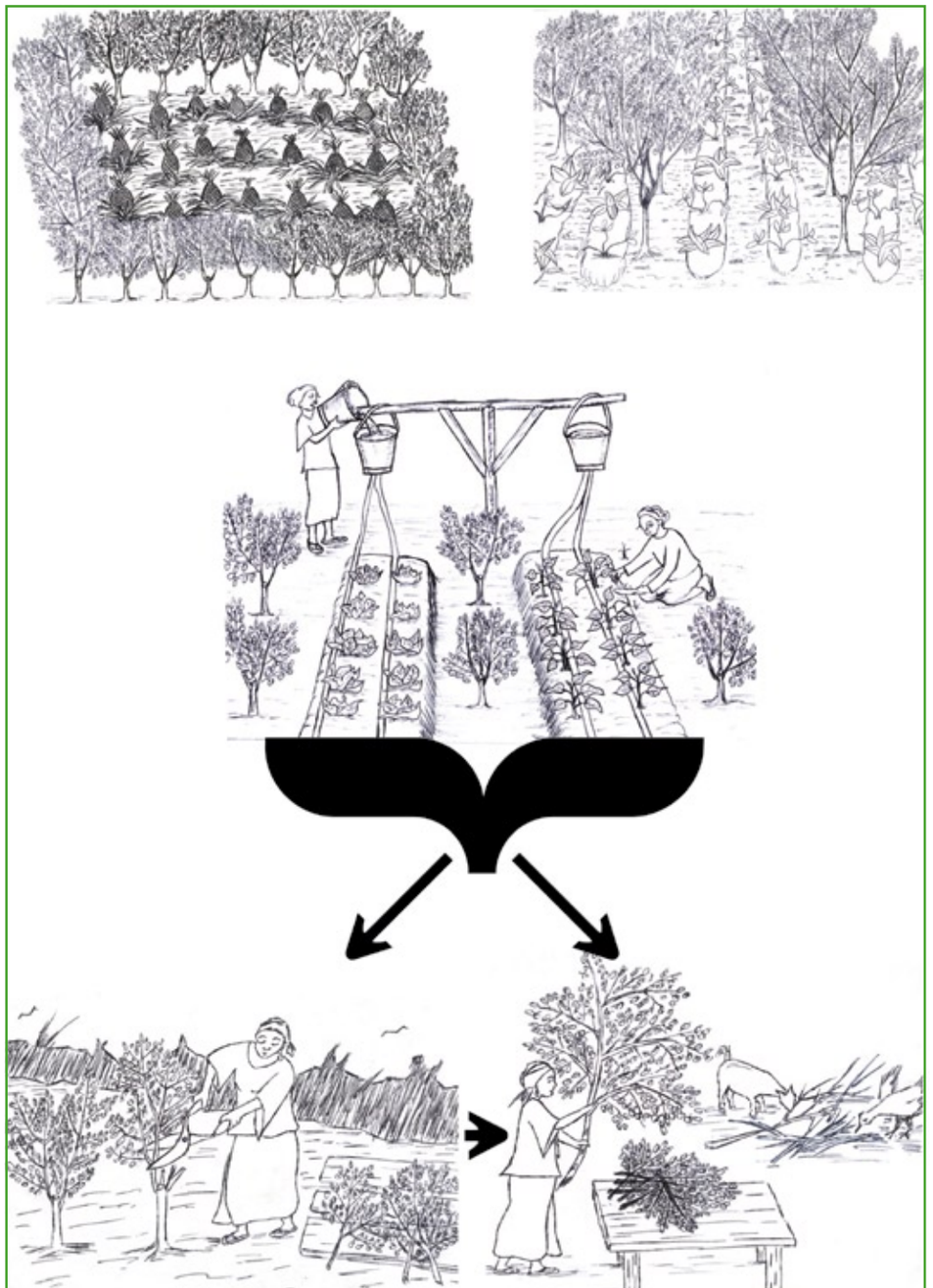
1 Intensive production of moringa leaves in Ghana.
2 Semi-intensive moringa farming in Togo (1 m x 1 m).



Moringa in agroforestry.

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It is advisable to avoid associating moringa with:

- Crops that require a lot of nitrogen, such as maize or cassava;
- Crops that require chemical treatments;
- Crops that can compete for light with moringa trees (millet, sorghum).

It is better to associate crops that can enrich the soil in minerals, especially in nitrogen like leguminous plants such as groundnut, soy or beans.

Seed production

Spacing must be much wider for fruit or seed production. Trees must be at least 2.5 m apart. Line and peg using a 3 x 3 meter triangular pattern for seed-producing farms. This will optimize plant population density.

5. Caring for the plants

Moringa requires a lot of care and maintenance to produce the expected yields.

Shaping the trees

As *Moringa oleifera* tends to produce long branches that grow vertically and produce leaves and fruits only at their extremity, yields will be low if the trees are left to grow naturally. The tree can grow to heights of about 3 to 4 meters in the first year and continue to about 10-12 m thereafter. It is therefore essential to give the trees a good shape when they are young, by enhancing lateral branching thus creating bushy growth.

1 Moringa agroforestry in Benin.
2 Moringa seed production in Ghana.

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Pinching the terminal bud on the central stem is necessary when the tree attains a height of 50 cm to 1 m. This will trigger the growth of lateral branches which must be pinched too. This will promote the growth of many lateral branches, increase yields and reduce the height of the tree. In addition, pinching reduces damage due to heavy winds and makes harvesting much easier.

Pinching can be done with the finger nails as the stems are tender. If the trees are older and pinching was not carried out early enough, the terminal stem can be cut with a sharp tool, just above a node. Cutting in the internodes will cause the rotting of the stem all the way down to the node below the cut, and will give way to diseases and parasites.

Irrigation

Moringa can germinate and grow without irrigation if it is sown during the rainy season. Its tuberous root develops in twenty days and allows young plants to endure drought. However, for optimal growth, it is advisable to irrigate regularly during the first 3 months after seeding.

Irrigation is also necessary to produce leaves all year long, including during dry seasons. Another option is to stop producing during these periods: the trees will shed their leaves but will not die. At the onset of the rains, a good pruning and adding some organic manure will ensure that the trees start producing many new branches and leaves.

Any suitable irrigation system can be used e.g. rubber hose, watering can, sprinkler or drippers. Ideally, irrigation should be done in the early morning, night or evening, to reduce evaporation. If water is scarce, mulching or a very superficial weeding will also decrease evaporation.

1 Well-pruned moringa trees.
2 Watering at the base of the plant.

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Irrigation needs according to climatic zone:

- In the Coastal zone (south Ghana): leaf production is possible all year long without irrigation, with a lower production during the dry season.
- In the Savannah zone (north Ghana): production is possible without irrigation but harvests will stop during the dry season.
- In the Sahelian zone (Niger, Burkina Faso): plantations must be irrigated almost all year long (every day during dry seasons, two or three times a week during wet seasons). It is also possible to irrigate only when water is available and to stop production during the dry season.

Weeding

Manual weeding with a hoe removes weeds and loosens the soil for good aeration. Weeding must be done regularly to avoid competition for nutrients, especially for nitrogen. If not weeded properly, the trees produce fewer leaves and the leaves at the base of the plant begin to yellow. Weeding must be more frequent when the plantation is young and the trees are small, allowing light to reach the soil.

It is advisable to weed an adult plantation at least 4 times a year, with a higher frequency during rain seasons.

A good option is to leave the weeds on the soil as a mulch to reduce evaporation and enrich the soil. Burying them is not necessary as tropical soils have a very low capacity to retain minerals over time. It is better to let the weeds progressively enrich the soil as they decompose. Burying plant residues must be especially avoided on sloping terrain, to limit soil erosion.

Weeding must be done early enough so that no seeds develop on the weeds. If fruits and seeds are present, weeds must be removed from the field.

1 and **2** Weeding.

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Mulching

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

Fertilizing

Moringa can produce large quantities of leaves, but only if it receives enough organic supplements. Its leaves are rich in proteins and minerals, which means that the soil needs to provide enough nitrogen and minerals to the plants.

Instead of chemical fertilizer, farmyard manure (animal dung mixed with plant residue) or compost (plant residue left to decompose on a heap) can provide the necessary nutrients as well as improve the soil structure. The best fertilization is ensured by mixing fast decomposing residue (animal dung, green and soft plant residue) with slow decomposing residue (straw, dry plant residue and thin branches).

Fertilization must be done during land preparation, before seeding. After it is important to apply manure or compost at least once a year, for instance before the rainy season, when the trees are about to start an intense growth period (pruning can also be done at this time). If there are two rainy seasons, two applications are advised.

1 Mulching after weeding.
2 Fertilizing with manure.

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Pruning

After the initial pruning to shape the trees (see page 23), maintenance pruning is required. This can be done at each harvest, if the leaves are removed by cutting all the stems above a certain height (see harvest). If leaves are harvested by plucking, or if the trees are left unharvested during the dry season, the bushy shape can be lost and a good pruning must be done at the onset of the rainy season. In Niger, the trees are cut down to 20 cm above the ground once or twice a year. If the main stem is too thick, terminal branches can be cut down as in the initial pruning. In any case, it is important to cut just above a node to reduce rotting of terminal parts.

In seed-producing farms, pruning helps induce more fruits, as well as larger fruits. Break the terminal bud when the plant is about one meter high to stimulate branching.

6. Pest and Disease control

Insects

The most common pests are grasshoppers, crickets and caterpillars. These insects bite and chew parts of the plant, causing the destruction of leaves, buds, flowers, shoots, fruits or seeds as well as the interruption of sap flow. These outbreaks are frequent in dry zones where moringa leaves strongly attract insects. It seems that these outbreaks occur at the beginning of the dry season when insects cannot find other tender, green material to feed on. The best solution, in this case, is to cut back the trees, leaving no green part apparent. The following growth is very vigorous if conditions permit (sufficient water supply). Concerning the Lepidoptera caterpillar, it is imperative to detect the outbreak at the beginning, at the shoot centre, in order to act before it is too late. Spraying must be aimed at the centre and the extremity of the shoots to reach the young caterpillars.

1 Intensive farming parcel after harvest by pruning (Ghana).
2 Growth after pruning.

In organic farming, *Bacillus thuringiensis* (sold under the brand name Batik) is an insecticide composed of bacteria specific to Lepidoptera larvae. It must be ingested to be activated, with no impact on humans, wildlife or pollinators. The waiting period before harvesting is only three days. This insecticide is a good alternative to chemical products, is authorised in organic farming and has the advantage of a being a guaranteed preparation. Other brands exist like Delfin or Scutello. These products should be stored, if possible, in a cool place, at least protected from strong heat. According to the producer Certis, Delfin can be stored for three years at a temperature of 30°C.

Neem extract can also be used against insects, if it is sprayed in time. The Suneem 1% from the Senegalese company Senchim is certified in CILSS (Permanent Interstate Committee for Drought Control in the Sahel) countries.

Termite attacks also cause damage to moringa plantations.
Some organic solutions exist for termite control:

- Applying neem seed cakes to the soil.
- Applying castor oil plant leaves, mahogany chips, tephrosia leaves or Persian lilac leaves around the base of the trunk.
- Heaping ashes at the base of the trunk.
- Building termite traps using bowls filled with wet straw, soil and other vegetable waste (wood chips, mango pits). The bowls are filled in the morning, turned up side down against the soil, the edges slightly buried and covered with a handful of dry leaves to maintain coolness. These traps should be checked every 24 to 48 hours.

If synthetic insecticides have to be used, choose the least toxic, like pyrethroids (Decis, Karate, Klartan). They remain active for 20 days or more, even in hot or windy conditions. Pyrethroids kill Lepidoptera eggs. Allow a 7-day minimum waiting period before harvesting, 14 days if the leaves are to be eaten raw. Avoid reapplying more than 2 or 3 times per season as this could favour resistance development to the pesticide and aphid attacks.

To find out more about phytosanitary products authorised for sale in CILSS countries, visit this website:
http://www.insah.org/protectiondesvegetaux/csp/pesticidautorise.html

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Fungal diseases

These diseases are by far the most serious in moringa farming. Brown spots can appear on the leaves and then spread to cover them entirely, turning the leaves yellow and killing them. This is caused by the fungi *Cercospora spp* and *Septoria lycopersici*.

Alternaria is also frequent: angular, dark-brown spots with concentric circles appear on the leaves. Black or brown marks appear on the branches as well. The fungus is known as *Alternaria solani*. The onset of the disease is hard to detect. Once the spots have appeared it is often too late to treat and defoliation is inevitable. It is therefore important to remember the periods when the symptoms appeared to be able to act earlier the following season. The effective, inexpensive products to use in both cases are made from either mancozeb or maneb.

The area around the trees, in organic farming, should be kept clear of weeds which are often hosts to diseases. The leaves and young shoots should be checked regularly for symptoms of fungal attacks. An early detection will save a lot of young plants from destruction. Neem leaf or seed extract can be sprayed on the plants to control pest and fungal attacks. This treatment is not as effective as using chemical products. The neem extract should be used as early as possible and sprayed repeatedly. Neem products can be produced locally and are not toxic for humans. The leaf extract is not as effective as the seed extract, but it can be used as well.

1 Fungus attack on moringa leaves.
2 Caterpillar attack.

HARVESTING AND TRANSPORTATION

1. Harvesting of shoots and leaves

The moringa tree has a compound leaf: one leaf is made up of multiple leaflets (see photo 2, page 33). What is referred to here as a leaf is precisely multiple leaflets attached to the rachis which stems from the branch (see the compound leaf in photos 2 and 3 on page 32).

Manual harvesting of shoots and leaves with a pair of shears, a sickle or a sharp knife is recommended. All shoots should be cut at the desired height, i.e. 30 cm to 1 m above ground. Mechanical harvesters could also be used for large-scale, intensive leaf production.

Harvesting can also be done by removing the leaves, picking them directly off the tree. They are easily removed at the base of the petiole. It is quicker to harvest this way but the trees will not have benefited from a good pruning and the following growth is therefore less vigorous.

A high level of hygiene should be maintained. Produce should be harvested at the coolest time of the day: early morning or late in the evening. It is important to make sure there is no dew on the produce before harvesting, especially in the morning, to avoid rot during transport.

2. Harvesting of seeds

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

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1 Intensive farming parcel harvested by pruning branches (Ghana).
2 and **3** Leaves separated from their branches (Burkina and Togo)

3. Transportation

Transportation in moringa leaf production is a very critical step in ensuring high quality leaves for consumption.

Two options:

- Cut big branches and transport whole to the processing centre if nearby, before defoliating (stripping or removing the leaves from the branch).
- Strip the leaves off the branches before transporting them to the processing centre. Leaves can be tied together in bunches by their stem or better, thinly spread out on trays or mesh to reduce temperature build up.

Freshly harvested material should be transported to the processing centre as quickly as possible to avoid deterioration.
Fresh moringa leaves, transported loosely, should be well ventilated. For shorter distances aerated baskets or perforated plastic containers should be used to transport the fresh leaves. Avoid open vehicles. Under no circumstances should people or goods be placed on top of leaves. Transportation should be during the cooler parts of the day: early morning, evening or night.
Leaves being transported over long distances should be in air-conditioned or refrigerated vans to keep them cool until delivery at the processing centre.

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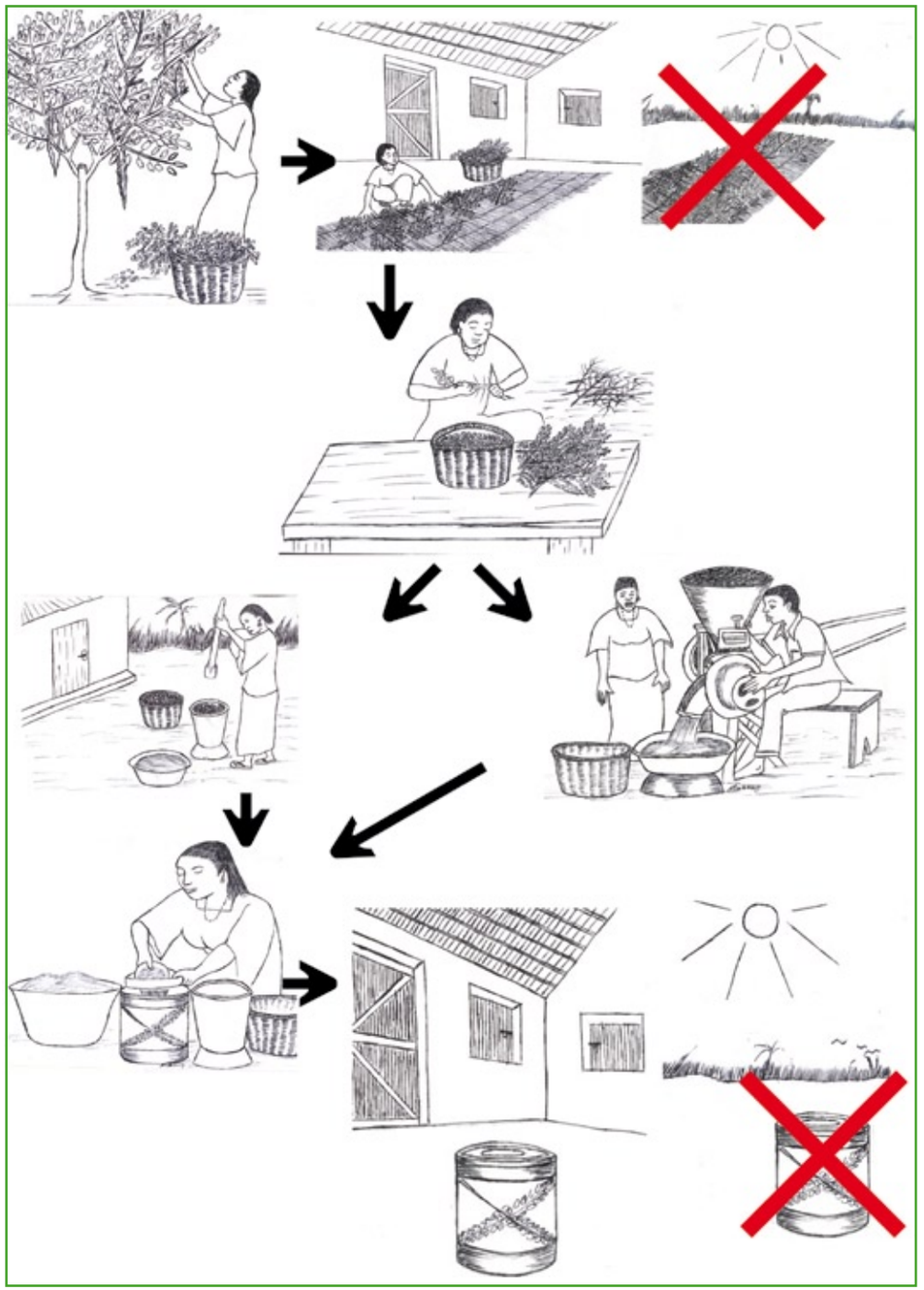
1 Removing leaflets from branches after harvest.
2 Leaflets prepared for transport on racks.

PROCESSING THE LEAVES



Making moringa leaf powder.

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

1. Stripping the leaflets

Strip all the leaflets from the leaf petiole. This can be done directly from the branches if the leaves have not been stripped off the main branch before transportation. At this stage, diseased and damaged leaves are discarded.

2. Washing

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

3. Draining

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

1 Removing leaflets directly from branches.
2 Removing leaflets at the workshop.
3 Washing leaves at the workshop.

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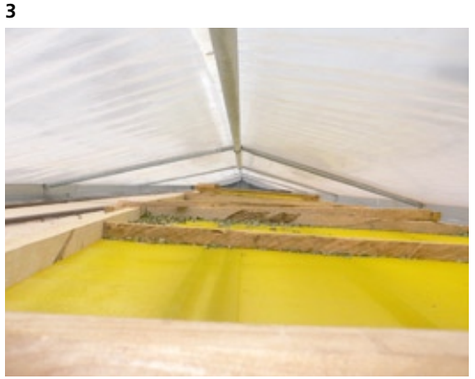

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1 First draining in perforated buckets.
2 Second draining on racks made with net.
3 Leaflet density on a solar dryer.
4 Racks for drying leaves in Burkina Faso.
5 and **6** Solar dryer.

4. Drying

There are three main methods for drying moringa leaves.

Room drying

Spread the leaflets thinly on mesh tied on racks (mosquito net mesh can be used) in a well-ventilated room. This room should be insect, rodent and dust proof. Air circulation can be improved by using ceiling and floor level vents protected with a clean filter to keep the sun and dust out. It is possible to use a fan, but the air must not be directly oriented towards the leaves, as it can increase contamination with germs in the air.

It is advisable to turn the leaves over at least once, with sterile gloves, to improve uniform drying. Leaves should be completely dry within a maximum of 4 days. The loading density should not exceed 1 kg/m^2.
However, room-dried leaves cannot be guaranteed mould-free with the maximum recommended moisture content of 10%. Therefore, we do not advise this method.

Solar drying

The solar dryer presented in the pictures is recommended but the polyethylene used should be UV treated or opaque (if the plastic is black, beware of temperature increases and be sure it does not go above 55°C). The air intake should be filtered to keep out dust. Organza or muslin cloth can be used as a filter.

Spread the leaves thinly on mesh and dry in the dryer for about 4 hours (Temperature range is 35°C–55°C on a very sunny day). The final product should be very brittle. We recommend solar drying for both small and large scale processing, particularly for those in rural communities where there is no electricity. Loading density should not exceed 2 kg/m^2.

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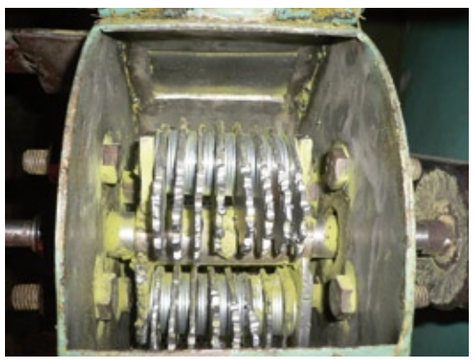

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1 Electric drying.
2 Electric drying racks (leaves, moringa twigs).
3 and **4** Hammer mill grinder.
5 A mill in Senegal.
6 Fine moringa powder.

Mechanical drying

Use electric or gas hot-air dryers (see photo). Drying temperatures should range between 50°C and 55°C. If temperature exceeds 55°C, leaves will "burn" and turn brown. Leaves should be dried until their moisture content is below 10%. We recommend this method for large scale leaf processing as this ensures year round production. Loading density should not exceed 2.5 kg/m^2.

5. Milling

Mill dry leaves using a stainless steel hammer mill. For personal or household use, leaves can be pounded in a mortar, or milled with a kitchen blender. Small-scale processors can use a burr mill or rent a commercial hammer mill for routine milling of their products.

6. Sieving

Sieve the leaf powder if need be. When you mill with a hammer mill, the fineness of the product will depend on the size of the screen used in milling. If too coarse, sift using a sifter with the desired screen size.

Recommended particle sizes are:

- Coarse (1.0 mm – 1.5 mm)
- Fine (0.5 mm – 1.0 mm)
- Very fine (0.2 mm – 0.5 mm)

7. Drying the leaf powder

Moringa leaf powder strongly attracts moisture and the product can reabsorb humidity during or after milling. **For this reason, moringa leaf powder should be dried at 50°C** for 30 minutes to reduce moisture content considerably below 7.5%.

PACKAGING AND STORAGE

Moringa leaf powder can easily be contaminated by moulds as it strongly attracts moisture. In addition finely milled powder makes it easier for bacteria to penetrate the particles.

1. Personal hygiene

All persons involved in the packaging of moringa leaf products must ensure that, while on duty, personal cleanliness and hygiene are maintained. Personal protective equipment (PPE) such as head caps, nose masks, disposable gloves, etc. must be used at all times.

2. Packaging in bulk

The temperature and humidity must be controlled in the packaging room, to avoid re-humidification of the product.

After drying, the powder is left to cool and packed into clean, single-use polythene bags and sealed. This is enclosed in a second polythene bag and heat-sealed. This is to maintain freshness and dryness prior to further use. The bags should be stored in a cool, dry place.

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1 and **2** Examples of opaque packaging (Ghana).

3. Final packaging

The temperature and humidity must be controlled in the packaging room, to avoid re-humidification of the product.

Moringa leaf products should be packaged in clean, dry and opaque containers made of materials that do not affect the quality of the product.

Each package must be properly sealed to prevent content leakage as well as moisture absorption.

4. Labelling

Each package of moringa leaf product must be legibly marked with the following information:

a) Name of product
b) Net content
c) Name and address of producer
d) Country of origin
e) Lot / batch identification number or code
f) Instructions for use
g) Production date
h) Nutritional information (optional)

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1 Non-compliant transparent packaging.
2 Compliant packaging (opaque).

USING MORINGA LEAVES FOR NUTRITION

Moringa promotional poster in Niger.

1. Nutritional content of fresh moringa leaves

Moringa oleifera leaves belong to the family of dark green leafy vegetables, a food group particularly rich in nutrients. In particular, *Moringa oleifera* leaves are a good source of proteins, calcium, iron, ß-carotene (converted to vitamin A in the human body), vitamin C and vitamin E.

In addition, *Moringa oleifera* leaves have a high dry matter content (around 20-25%) compared to most other plant food sources (generally around 10%). This makes it even more beneficial as a fresh vegetable since 100 grams of fresh leaves will bring twice as much nutritive material as 100 grams of most other vegetables.

Graphs 1 to 5 on page 50, show the nutrient content range of moringa leaves, comparing them either to foods high in these nutrients or to other leafy vegetables. These graphs show that the moringa leaf is a food particularly rich in nutrients compared to other healthyfoods. The moringa leaf is not the only leafy vegetable in this category: others such as amaranth and cassava leaves also have comparable characteristics.

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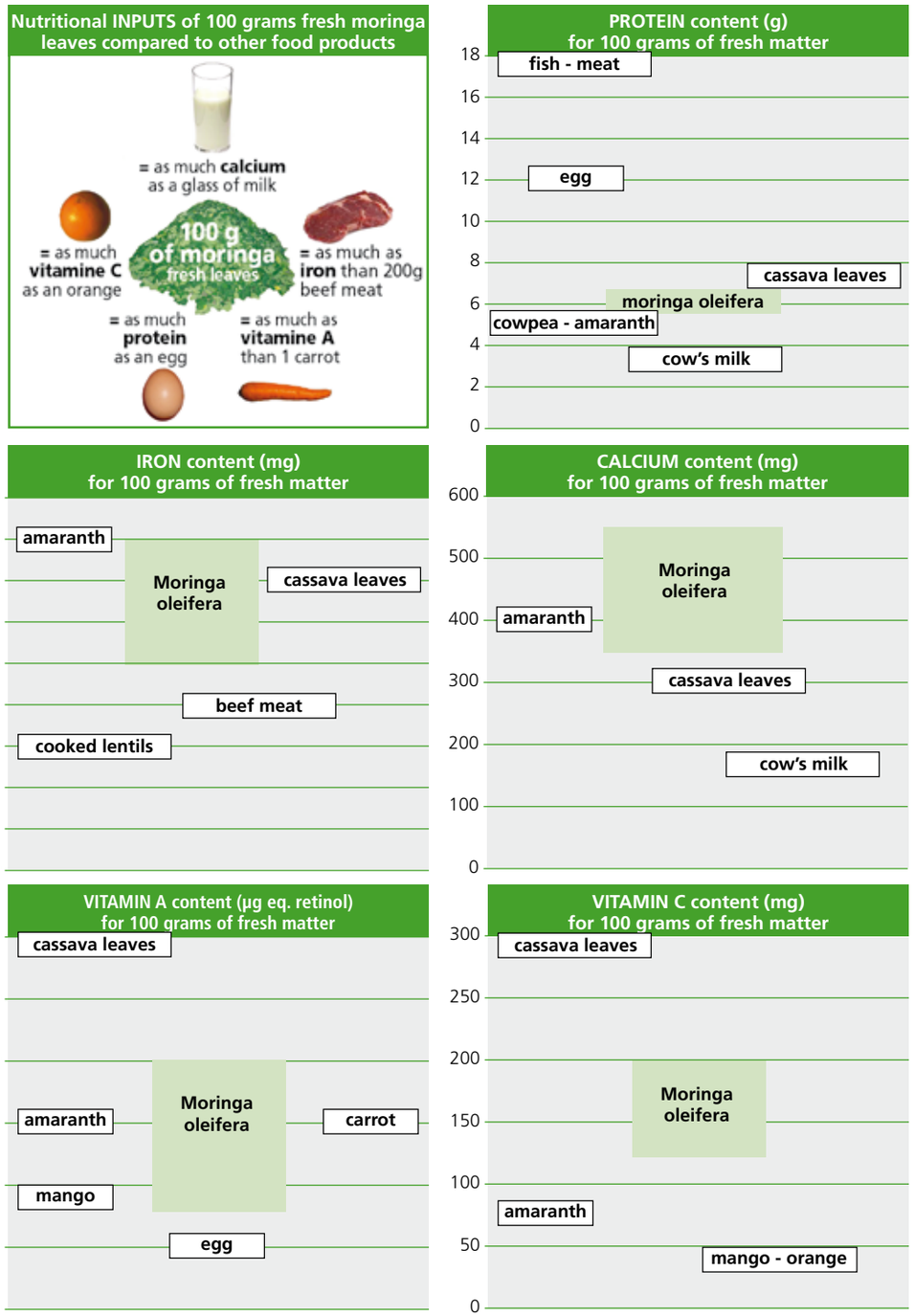
1 Promotional campain on eating moringa leaves in Togo.
2 Cooked moringa leaves.



Graphs 1 - 5

Table 5 gives the mean nutritional values of fresh *Moringa oleifera* leaves. These values can vary according to many factors such as environmental conditions (soil, climate), farming methods (irrigation, fertilizers…), maturity of the leaves (dark green, mature leaves are generally richer than light green, young ones), harvesting season, and to a lesser extent, the genetic background of the trees.

Table 5
Mean nutritional values of 100 grams fresh* Moringa oleifera *leaves.

Dry matter	20-25%
Proteins	5-7 grams
Total ash (= total minerals)	2-3 grams
Minerals	
Calcium (Ca)	350-550 mg
Potassium (K)	200-500 mg
Magnesium (Mg)	80-120 mg
Phosphorus (P)	50-120 mg
Iron (Fe)	5-8 mg
Manganese (Mn)	1,2-2,5 mg
Zinc (Zn)	0,4-0,6 mg
Copper (Cu)	0,2-0,3 mg
Vitamins	
Vitamin C	120-200 mg
Vitamin A (as ß-carotene)	1500-4000 µg eq. retinol
Vitamin E (as α-tocopherol)	150-200 mg

Eating 100 grams fresh *Moringa oleifera* leaves provides you with as much protein as an egg, as much calcium as a big glass of milk, as much iron as a 200 grams beef steak, as much vitamin A as a carrot and as much vitamin C as an orange.

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Indeed, 100 grams fresh *Moringa oleifera* leaves are enough to cover:

• 30 to 100% of the daily recommended intake of calcium (30 to 50% for teenagers, 40 to 60% for adults, children and pregnant and breastfeeding women, 80 to 100% for young children below 3 years old)
• 25 to 80% of the daily recommended intake of iron (25% for pregnant women, 40-60% for teenagers and women, 50 to 100% for men and children).

As for vitamins, the recommended daily intake for vitamin A varies from 400 µg retinol equivalents (young children) to 1,000 µg retinol equivalents (breastfeeding women). Therefore, 100 grams of fresh *Moringa oleifera* leaves could theoretically cover 100% of daily needs, but this is highly variable depending on storage conditions and how they are eaten, as vitamin A degrades over time and when exposed to light or heat.

Similarly, 100 grams of fresh *Moringa oleifera* leaves could cover 100% of the vitamin C requirements, for which the recommended daily intake varies from 60 mg (young children) to 130 mg (breastfeeding women), but this vitamin degrades quickly with time and during cooking.

For optimal nutrient retention, it is advised to consume fresh leaves shortly after harvesting and to cook the leaves for a short time (a few minutes only), or even to eat them raw if they are young and tender.

1 Tasting a moringa dish (Togo).
2 Moringa leaves and powder.

2. Nutritional content of dry moringa leaf powder

Another way of consuming *Moringa oleifera* leaves is to dry them and reduce them into powder, making it easier to store and use at any time. To ensure the good nutritional and microbiological quality of the leaf powder, its water content has to be lower than 7%, the drying time should be as short as possible and the drying temperature not too high (no more than 50-55°C).
Even if a large amount of the vitamins are lost during drying and storage, the leaf powder still constitutes a very rich nutritional supplement, since it is a concentrate of the leaves (see table 6).

Table 6
Mean nutritional values of 100 grams* Moringa oleifera *leaf powder.

Dry matter	90-95%
Proteins	20-26 grams
Total ash (= total minerals)	8-11 grams
Minerals	
Calcium (Ca)	1600-2200 mg
Potassium (K)	800-1800 mg
Magnesium (Mg)	350-500 mg
Phosphorus (P)	200-600 mg
Iron (Fe)	18-28 mg
Manganese (Mn)	5-9 mg
Zinc (Zn)	1,5-3 mg
Copper (Cu)	0,7-1,1 mg
Vitamins	
Vitamin C	15-100 mg
Vitamin A (as ß-carotene)	4000-8000 µg retinol eq.
Vitamin E (as α-tocopherol)	80-150 mg

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10 grams of Moringa oleifera leaf powder per day cover:

Calcium

• About 30% of the recommended daily intake for children between 1 and 3 years old.
• About 25% of the recommended daily intake for children between 4 and 9 years old as well as adult women.
• About 15% of the recommended daily intake for teenagers and women over 55.

Iron

• About 30% of the recommended daily intake for children between 1 and 12 years old.
• About 15% of the daily recommended intake for teenagers.
• About 20% of the daily recommended intake for adults over 55.
• About 12% of the recommended daily intake for adult women.
• About 7% of the recommended daily intake for pregnant women.

Vitamin A

• 50 to 100% of the recommended daily intake for all population categories.

Moringa leaf powder can be used somewhat like dried spirulina, a nutritionally rich, green seaweed, often used as a dietary supplement. Table 7 compares the nutritional value of the two plants.

1 Tasting moringa in Togo.
2 Moringa sauce.

Table 7
Comparison of the nutritional composition of spirulina powder and* Moringa oleifera *leaf powder. Values for 100 grams of powder.

Element	*Spirulina platensis*	*Moringa oleifera*
Humidity	3%	7%
Digestible proteins (g)	40	20-26
Potassium (mg)	1400	800-1800
Calcium (mg)	700	1600-2200
Phosphorus (mg)	800	200-600
Magnesium (mg)	400	350-500
Iron (mg)	100	18-28
Vitamin A (µg retinol eq.)	7000	4000-8000
Vitamin C (mg)	0	15-100
Riboflavin (µg)	3500	8800
Nicotinamid (µg)	4000	10400

Moringa leaf powder can be stored for some time before it is consumed. If so, the leaf powder has to be stored in a water- air- and light-proof container to preserve as much vitamins as possible and avoid microbial contamination. In storage, the protein and mineral contents will be preserved for up to six months, whereas a loss of up to 50% of vitamins can be reached after six months of storage.

Once the container is opened, the leaf powder should be consumed quickly (within one week) since its water content will increase and it will be exposed to microbial contamination. For this reason, it is advised to package leaf powder in rather small containers.

3. Nutritional content of cooked moringa leaves

Fresh moringa leaves can be eaten raw, if they are very young and tender, but usually they are cooked. Even if cooking the leaves destroys a part of their nutrients, notably vitamins, others become easier to assimilate. For this reason, it is important to consider various ways of cooking moringa and to understand how to preserve the maximum amount of nutrients. This can be achieved by associating moringa leaves with other ingredients that enhance the availability of nutrients, by cooking the leaves only for a short time, or by keeping the liquid (water, sauce) in which the leaves are cooked. Using moringa leaf powder is also a way of preserving nutrients (although some have been lost during drying and storage), as the powder can be added to food after cooking.

Vitamin C

A study from Sri Lanka showed that on average, leafy vegetables lose 32% of their vitamin C content when they are boiled for five minutes, and 54% in ten minutes. Steaming is less damaging, with 15% loss in five minutes and 39% loss in ten minutes. Cooking moringa leaves or moringa leaf powder the least possible time is thus a good way to preserve the vitamin C content.

Beta-carotene

The World Vegetable Centre (AVRDC, Taiwan) showed that the retention of total carotene and beta-carotene of moringa leaves was enhanced by adding oil to the leaves during pressure cooking (76-99% of retention with oil against 46-63% without).

Iron

The bioavailability of nutrients is the ability they have to be digested and used by the human body. The bioavailability of the iron provided by plants is lower than when provided by meat. A good way to improve the availability of iron to the body is to add vitamin C to the dish. This can be done by using lemon juice, lemon peel or fresh tomatoes.

AVRDC demonstrated that boiling moringa leaves in water enhanced the *in vitro* iron bioavailability of fresh leaves and dried powder by 3.5 and 3 times, respectively. In addition, boiling moringa leaves in water enhanced aqueous antioxidant activity.

This shows that cooking moringa leaves does not necessarily have a negative impact on nutrient intake. The heat destroys some of the vitamin C, but improves the assimilation of iron. The best option is to vary consumption modes.

4. Water soluble and fat soluble vitamins

Vitamin C and all the B vitamins contained in the moringa leaf are water-soluble. Other vitamins are soluble in fat: such is the case of vitamin A (ß-carotene) and E (α-tocopherol).

When cooking fresh or dried moringa leaves, the cooking water should be kept to benefit from the vitamins B and C, soluble in water. In addition, to render the fat-soluble vitamins A and E available, it is suggested that the leaves be cooked using oil or other sources of fat.

Ideally, the leaves should be quickly boiled in a small quantity of water. Add both leaves and the cooking water to a sauce containing a source of fat. This way both water-soluble and fat-soluble vitamins, only slightly diminished by cooking, are made available.

Research concerning the nutritional value of food now gives an increasing importance to how the foods are cooked and the interaction between ingredients. **The moringa leaf cannot be summed up in one nutritional formula: the culinary and cultural traditions are fundamentally important. This branch of research has opened up a vast road to be explored, not only with nutritionists but also with cooks and African consumers.**

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1 Togolese moringa dish.
2 Mélanie Broin tasting a moringa dish in Togo.

CONCLUSION

The future of moringa

Farmers in rural or peri-urban Africa can easily undertake moringa leaf production. Its production creates employment, requires little financial investment and can be cultivated without using chemicals. The keys to a successful farm are pruning the trees to obtain bushy leaf-growth and regular but limited amounts of water and organic manure. By following these recommendations, a moringa plantation can produce leaves in abundance all year-round.

Processing is also an accessible activity that generates income for food processing businesses and rural farmers' associations. Sun drying is an inexpensive, efficient method used to obtain quality results. Milling does not require specific equipment; the mills widely used in Africa are perfectly adapted. Packaging has to be airtight and lightproof. The fundamental aspects of processing are hygiene and humidity control to ensure that the leaf powder stays perfectly dry until packaging.

Moringa leaves are an inexpensive source of proteins, vitamins and minerals for developing countries. Dried and milled, moringa leaves are easily stored and used by families who can then add the powder to their daily meals. The powder can also be used by food businesses to enrich their products in nutrients. Moringa leaves can help decrease developing countries' dependence on imported goods, such as vitamin and mineral complexes that ward off nutritional deficiency but are too expensive to be used in a sustainable way.

Moringa is categorised as a leafy vegetable like the leaves of the baobab, manioc, sweet potato, amaranth and hibiscus. These local leafy vegetables, either cultivated or collected, are all highly concentrated in nutrients. Their use had for a long time been shadowed by European vegetables considered more modern, such as cabbage, carrots etc.

Though today, African consumers are showing a rising interest for these leafy vegetables, not only for their low cost but also for their taste and health benefits. The importance research programmes and NGOs have given these products, before considered outdated, has also contributed to revamping the image of local leafy vegetables. This increase in interest for local foods and culinary traditions is part of a worldwide trend.

The moringa leaf is a nutritionally rich, ecological, economical vegetable available in practically all countries with malnutrition issues. It is therefore essential to develop the production and consumption of this "green superfood".

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Moringa Association of Ghana (MAG)

The Association was created in November 2006 during the second international meeting on moringa organised by Moringanews in Accra. Membership of MAG is now three hundred and fifty strong (350). MAG's mission statement is to develop the moringa sector by coordinating the activities of members and other stakeholders so as to achieve a competitive advantage in local and global markets and to ensure product safety.

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MORINGANEWS
Moringa and Plant Resources Network

The Moringanews association's mission is to promote the use of moringa and other plants with a strong potential to impove living conditions in developing tropical countries. The Moringanews network and its website were created in 2002, as a result of the first international summit on moringa, organised in Tanzania by the PROPAGE association. Moringanews has been an association in its own right, registered in Paris, since 2005. It disseminates scientific information, fosters and carries out research and development projects and facilitates the coordination of contributers through its website and the organisation of international conferences.

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CTA

The Technical Centre for Agricultural and Rural Cooperation (CTA) was established in 1983 under the Lomé Convention between the ACP (African, Caribbean and Pacific) Group of States and the European Union Member States. Since 2000, it has operated within the framework of the ACP-EU Cotonou Agreement. CTA's tasks are to develop and provide products and services that improve access to information for agricultural and rural development, and to strengthen the capacity of ACP countries to acquire, process, produce and disseminate information in this area.

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The Centre for the Development of Enterprise (CDE) is an ACP (African, Caribbean and Pacific)/EU joint Institution created in the framework of the Cotonou Agreement. CDE's mandate given in the Cotonou Agreement positions the Centre as an Institution dedicated to support private sector development in ACP countries. Its objective is to ensure the development of professional ACP enterprises operating in the private sector. The Centre provides non-financial services to ACP companies and to joint initiatives of ACP and EU economic operators in various economic sectors, with the main aim to create, consolidate and increase and competitiveness of ACP enterprises.

CDE's financial resources mainly come from the European Development Fund (EDF).

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Growing and processing moringa leaves

The moringa leaf is a nutritionally rich, ecological and economical vegetable available in practically all tropical countries. It is therefore essential to develop the production and consumption of this "green superfood".

Moringa leaves are an excellent, concentrated source of proteins, vitamins and minerals. Of the 120 vegetable species tested for their nutrient content, antioxidant activity, gustatory qualities and the facility with which they are grown and processed, moringa leaves were top ranked by the World Vegetable Centre (AVRDC).

Moringa oleifera grows quickly and is easy to cultivate. The moringa leaf, fresh or processed into dried powder, can be used as an every-day food item in a multitude of ways: in ready-made meals, juices, breads, pasta, fritters, condiments, instant soups… This food can be used in households, school cafeterias, dispensaries, maternity wards, nutrition rehabilitation centres, as well as in restaurants and supermarkets.

This handbook is destined to improve moringa leaf farming and processing in order to meet top sanitary and nutritional standards. For the first time, the techniques of moringa production, perfected by African farmers, have been compiled, verified and presented in an easy-to-use, precise manner. The steps in the leaf-processing phase have been tested and improved based on information gathered from both Africa and Asia. Finally, the analysis of reliable scientific reports has helped establish average nutrient values of fresh or powdered moringa leaves.

Moringa is an exceptional resource for developing countries. Processed or fresh, the moringa leaf is not only a new, promising source of income and employment, but also an outstanding, nutritionally rich vegetable for families and markets.

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