Leaf Concentrate:

A Field Guide for Small Scale Programs

by David Kennedy and Leaf for Life

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ABOUT THIS MANUAL

It is the purpose of this manual to help people interested in health, nutrition, agriculture, and environmental issues to be able to begin making and using leaf concentrate in towns and villages in developing countries. This manual is an ongoing work that will be periodically updated. It deals almost exclusively with small or village scale production systems. There is very little information on industrial scale production. This manual should be useful to anyone involved in a small leaf concentrate program, but is not intended to substitute for hands on training. Eventually, the manual will be matched with a training film on videocassette and a 3 - 5 day training course offered at least once a year. You may want to photocopy some of the information and charts in this manual for people who need to refer to one aspect of leaf concentrate work, but who do not need the entire manual.

Throughout the manual I use the terms "leaf concentrate", "LC", or occasionally "leaf curd" to describe a food made from coagulating green plant leaf juice. This food has also been called "leaf protein" and "leaf protein concentrate". Most of the references relate to projects linked with or run by a small voluntary organization called Find Your Feet in Great Britain and Leaf for Life in the USA.

Information and ideas for this manual came from a lot of people, most importantly Walt Bray, Glyn Davys, and Boone Guyton. Drawings and help with layout also came from several people, including Beth Rosdatter, Alison Craig, Susan Lynn, Therese and Sherri Hildebrand, Jose Leon and Danne Lakin. You are most cordially invited to join in the development of this exciting 'Food for the Future'. Leaf For Life appreciates any criticisms or suggestions that may help to improve this course. We also like to hear of problems, solutions, recipes, or good ideas that people run into while working with leaf concentrate.

Thank you and the best of luck.

INTRODUCTION

In the last half of the 18th Century a Frenchman named Rouelle discovered that a vegetable curd could be made by simply heating the juice squeezed from hemlock leaves. Little was done with this information until World War II when the British, fearing that their food supplies could be cut off, began searching for alternative sources of protein. N.W. Pirie led a team of scientists in the development of equipment to extract protein from green leaves. Using alfalfa, wheat leaves, mustard greens, and other plants, the team did a great deal of research on the use of these leaf concentrates. While this team and a few other individuals continued working on leaf concentrates, it wasn't until the 1960's that interest in making curd from leaves picked up again. Work began advancing on two quite different fronts.
In several highly developed countries work began on using dried leaf curd to enrich animal feeds. At the same time Find Your Feet (LEAF FOR LIFE), a small voluntary organization based in London, England, began promoting the use of leaf concentrate to counter malnutrition in children living in tropical villages and towns.

Several studies were undertaken to establish the safety and nutritional value of the leaf concentrate in the diets of children. Find Your Feet (LEAF FOR LIFE) has since started programs to teach women how to prepare leaf concentrate for malnourished children in Mexico, India, Bolivia, Sri Lanka, Ghana, Nicaragua and Bangladesh.* These programs have received financial support from the United Nations, the European Economic Community, Mexico's DIF, the British Overseas Development Agency, the Rotary Club International, employee programs from Delta Airlines and Sun Microsystems, as well as many private trusts and individual supporters.

In all of its projects Leaf For Life has worked to train women to make high quality leaf concentrate from local leaves, with the aim of improving the diet of members of their communities who are vulnerable to malnutrition. Usually this means children, pregnant and nursing mothers, and the elderly. Through the work done in these projects and work done in England, the U.S., India and Sweden the process of making and using leaf concentrate is gradually becoming easier and more economical.

Machinery is constantly being improved and new recipes are tried every year. The workshops where leaf concentrate is made are becoming more efficiently organized and the cost of starting a program is dropping.

* We know of two other organizations using leaf concentrate in small nutrition programs. Leaf Nutrient Program has begun a project in Coahuila, Mexico and the Pakistan Council for Scientific and Industrial Research did the same type of work at an orphanage near Lahore, Pakistan. Their addresses, along with those of other sources of information on subjects related to leaf concentrate are listed in the back of this manual.

**WHAT IS LEAF CONCENTRATE?**

Leaf concentrate is an extremely nutritious food made by mechanically separating indigestible fiber and soluble anti-nutrients from much of the protein, vitamins, and minerals in certain fresh green plant leaves. Because it is so rich in beta-carotene, iron, and high quality protein, leaf concentrate is very effective in combating malnutrition, especially the anemia and vitamin A deficiency which are prevalent among children and pregnant women in most developing countries. It is easily combined with a variety of inexpensive foods to make culturally acceptable dishes.

Because it takes more direct advantage of solar energy, a leaf crop can produce more nutrients per hectare than any other agricultural system. Leaf crops can usually be
produced with less environmental impact than grains. The simple technology of making leaf concentrate offers a means of capturing a much greater part of the leaf harvest for direct human consumption. The fiber that is separated can be used to feed animals, and the left over liquid, or "whey" can be used to fertilize plants, so nothing is lost.

**WHY LEAF CONCENTRATE WORKS**

Agriculture is basically a biological system for collecting the energy of the sun in ways that are useful to humans. Green leaves are the solar energy collectors. The more surface area of green leaves exposed to the sun's light, the more energy can be captured from a given parcel of land.

Chlorophyll, the pigment that makes leaves (and leaf concentrate) so green, converts carbon dioxide from the air, water and sunlight into simple carbohydrates. These combine with each other to make sugars and starches, which supply our bodies with energy. They also combine to make fibers like cellulose and lignin that make useful things like paper, cotton cloth, and wood possible. These simple carbohydrates formed in the plant's green leaves also combine with nitrates from the soil to make proteins, which are often called the building blocks of life.

The basic foods that we eat are almost all created in the green leaves of plants. They are then translocated to be stored in seeds, tubers, and fruits. When we eat a tortilla, a sweet potato, or a banana we are eating food made by the green leaves of the corn plant, the sweet potato plant, and the banana plant. Moving the food from the leaf to the seed or the tuber or the fruit costs the plant energy. This reduces the amount of available food because the plants burn their own sugars and starches to get this energy. Of course, much more of this food becomes unavailable when the seeds or tubers are fed to animals. This explains why animal products like meat, milk, and eggs are usually more expensive than plant products.

When we grow wheat or other basic grains the young leaves of the plant are relatively efficient at converting the sun's energy to food. However, for much of the time that the grain occupies our best farmland it is producing very little food. As the leaves turn yellow and brown they stop producing food and the plant is simply drying the seed so that it will be a very compact food storage container. These grains are certainly convenient food. Because the grains have far less water and fiber than the green leaves, as well as generally milder flavor, they have been a more useful and popular food.

The leaf concentrate technology offers a simple means of removing much of the water and almost all of the fiber from the green leaves. This can make green leaves a much more attractive food. While leaf concentrate will never replace grains, it does offer a major new source of food in the human diet. Combining inexpensive easily grown starchy crops like cassava, bananas, and breadfruit with leaf concentrate could provide superior nutrition to a grain based diet for millions of people in the tropics.
directly tapping the tremendous productivity of leaf crops, leaf concentrate can produce more protein and most other important nutrients per hectare than other agricultural systems.

How quickly this food technology is put into widespread practice will depend mainly on economics. The economics of leaf concentrate production is closely tied to the scale of operation and how well the fiber that remains when the concentrate is separated from the leaves is utilized. Usually the most economical use of this fiber is to feed it to cows, goats, sheep, horses, rabbits, or guinea pigs. Because the fiber is so finely chopped up animals can absorb the nutrients in it more readily than they can from hay or forage crop. In a sense, the grinding of the leaves for making leaf concentrate acts in the same way as the animals chewing the leaves for a long time. This residual fiber is also lower in moisture than the original leaf crop so it is easier to dry for hay or to preserve as silage.

Ultimately what makes leaf concentrate work is that it is based on the careful observation of some of the biological processes that are fundamental to understanding the nature of food. How well it works will be determined by how well people like yourself can apply these observations to create practical systems of leaf concentrate production.

ADVANTAGES OF LEAF CONCENTRATE

1. Leaf concentrate is an extremely nutritious food. It is richer in vitamin A and iron than any commonly available foods. Deficiencies of these two nutrients are two of the most serious and prevalent health problems in the world today. Leaf concentrate is also a very good source of high quality protein and calcium, as well as several other important nutrients.

2. It is a very efficient way of using land to produce food, yielding roughly three times as much protein per hectare as grain crops and five to ten times as much per hectare as animal raising.

3. While the green color of leaf concentrate foods is unfamiliar, the acceptance of these foods by children in a dozen different countries has been excellent. As most parents know, many children all over the world do not like to eat dark green leafy vegetables. We do not have this problem when these leaf crops are converted into leaf concentrate foods.

4. Leaf concentrate is relatively easy to make. People with little training or education can make it in rural villages.

5. It offers a very nutritious food at prices below what foods like meat, cheese, eggs, or powdered milk cost. It is usually the cheapest dietary source of vitamin A and iron wherever it is made.
6. It is an environmentally sound agricultural technique. Leaf crops protect the soil from the erosion that has been destroying grain production land. Pesticides are not needed to protect leaf concentrate crops from cosmetic insect damage since the leaves are ground to a pulp immediately after harvest.

7. Nothing is wasted in leaf concentrate production. The residual fiber makes an excellent feed for cows, goats, sheep, horses, rabbits, or guinea pigs. It can also be used to enrich the soil or in production of bio-gas for cooking. The left over liquid is rich in nitrogen and potassium, and makes a good fertilizer. It has been used to produce ethanol as well.

8. Unlike dark green vegetables, leaf concentrate is easy to preserve. It can be dried, converted to pasta, made into drink mixes or syrups, salted or pickled.

9. Many of the anti-nutrients found in leafy foods are removed through the leaf concentrate process. The hydrocyanic acid, nitrates, goitrgens and free oxalic acid that limit the usefulness of many leaf crops in the human diet are almost completely removed when the leaves are converted to leaf concentrate.

10. Leaf concentrate uses far less fuel to prepare than beans, the main high protein food of the world's poor.

11. There have been no known cases of allergic reaction to leaf concentrate since 1975 when the standard processing heat was raised to a minimum of 90 °C (195 °F). However, many children are intolerant of other nutrient dense foods like fish or cheese, and genetic lactose intolerance makes milk a less than ideal food for children in some regions.
DISADVANTAGES OF LEAF CONCENTRATE

1. Good leaf yields require a steady supply of water. In many locations there are long dry seasons and irrigated land is at a premium. In arid lands the water requirements of lush leaf crops are usually excessive and focusing on improving water thrifty crops like sorghum, millet, buffalo gourd, tepary beans, and acacias is a more realistic strategy.

2. Most people are not accustomed to eating many dark green foods.

3. Fresh leaves are very perishable. They must be processed soon after they are harvested or the quality and yield of leaf concentrate goes down.

4. Fresh leaves are heavy as is the residual fiber and 'whey'. These means transportation costs will be high unless processing can be done very close to the leaf crop field.

5. While domestic scale production can be done with inexpensive commercial grinders and blenders, larger scale equipment is not currently available commercially and must be custom built.

6. The vitamin C in fresh leaves is lost during processing.
SECTION I

HOW TO MAKE LEAF CONCENTRATE

EIGHT BASIC STEPS

1. **Harvest** fresh green leaves from plants known to be good sources for leaf concentrate. (More information on choosing the right plants is in the section on growing leaf concentrate crops in this manual).

2. **Wash** the leaves well in clean water to remove dust and dirt.

3. If the leaves are large or there are a lot of tough stems **cut** or tear the leaves into pieces the length of a finger. (This step is unnecessary with some of the leaf grinders like the impact macerator)

4. **Grind** the leaves to a pulp.

5. **Press** as much juice as possible from the pulped leaves.

6. **Heat** the juice rapidly to the boiling point.

7. **Separate** the curd that forms in the heated juice in a tightly woven cloth.

8. **Press** as much liquid as possible out of this curd.

**What remains in the cloth is LEAF CONCENTRATE**
1. **Cut fresh green leaves**

**HARVESTING LEAVES**

Normally we prefer to harvest leaves early in the morning and take them immediately to the leaf concentrate workshop where they are washed in clean water then ground up as soon as possible. Any long delays in processing from the time the leaves are cut until the leaf concentrate is finished will lower the quantity or quality of the final product.

The leaves are cut off as low on the plant as will allow for rapid regrowth. It is very important not to cut too low, especially with plants like cowpeas, as they will die rather than produce more foliage. Cutting cowpeas at 5 cm rather than 20 cm (2 rather than 8 inches) will mean that the crop needs to be reseeded at least twice as often and the annual leaf production will be several tons less per hectare. The ideal height for cutting leaf crops varies from crop to crop and even among varieties of the same crop. It is relatively easy to test regrowth at a few different heights to see what works best with the crop you are using.

Perhaps more important than the height at which a crop is cut, is the time. Leaves are best for making leaf concentrate when their content of protein is highest and their moisture content is between 75-85%. As a very general rule, for most crops their leaves are at peak moisture content early in the morning and a peak protein content just before flowering. A schedule of harvesting can be worked out that takes into account seasonal fluctuations of leaf production as well as any changes in the processing capacity or end use of leaf concentrate that take place during the year.

Equipment for harvesting leaf concentrate for small scale projects is very simple. A Nicaraguan leaf concentrate worker developed a handy cutting system using a sharp machete and a special stick with a curved metal hook on the end. He uses the hooked stick to hold the plants erect to cut with his machete and then to toss the cut plants into piles. Generally two handed scythes or swing blades are more effective for cutting alfalfa and most other leaf crops than machetes or knives. Cowpeas tend to get too tangled to cut with a scythe, but with a little practice this is a much faster method for cowpeas as well. European scythes are often made with better blades and better balance than cheaper stamped steel ones available in the US and many other countries.

On a slightly larger scale a sickle bar or reciprocating mower could be used to cut the crop. Several implement companies make sickle bar mowers that will slice the leaves off cleanly at an even height. This height may be lower than optimal for some crops and may need to be adjusted. Some of these are designed to be used with tractors or horses, but
there are also some designed for use with "walking tractors" like the BCS or the Gravely, that are smaller, cheaper, and more flexible in use than larger tractors.

One type of leaf cutter that doesn't work for leaf concentrate is a rotary lawn mower. These have high-speed rotary blades that chop the leaves too finely before they can be washed. The rotary motion also tends to suck up dirt and dust that are very hard to wash out of the cut leaves. Some early tests of leaf concentrate showed very high levels of ash because the leaves were cut with a rotary lawn mower and the dust was never adequately removed.

Strimmers or Weed Eaters can also be useful for leaf harvest. There is a wide range of these tools available with different cutting heads and we have not tested them thoroughly. Michael Cole in England uses a strimmer with a metal cutter for alfalfa. We are trying to employ a Strimmer fastened to small bicycle wheels for wet weather weeding in Nicaragua, and it is possible that this technique can be employed in leaf harvest as well.

**Transporting Leaves**

After the leaves are cut they are usually tossed into piles. Using light leaf rakes to pull the harvested crop into windrows and hayforks to load them onto carts is much faster than packing the leaves into sacks by hand. The piles are then picked up and loaded into sacks or piled directly into a cart or wagon or truck. Whatever is most convenient for your project to haul the leaves is probably fine.

We have had some problems with bicycles and with trucks. The bicycles don't have the hauling capacity needed and sometimes the amount of leaf concentrate we could make was limited by what could be hauled on one bike trip. The three wheel bikes designed for haulage could be better, but they are made for paved streets and won't do well getting in and out of muddy fields. We found that trucks tend to be too valuable and have many other competing uses. The use of trucks may be freely offered at the beginning of a new project when enthusiasm is high, but they can become much less available after the novelty of the program or the presence of foreigners passes. They are frequently broken down, even if otherwise available.

Wheelbarrows and simple two wheel pushcarts may work well if the amount of leaves is not great and the distance between the leaf field and processing workshop is only a couple hundred meters. For greater weights or greater distances carts drawn by horse, donkey or ox may be more appropriate. The cost of transporting leaves should definitely be figured to be able to offset some of the cost by offering some of the residual fiber to the owner of the animals for feed. If fiber and "whey" need to be hauled somewhere, it may be reasonable to arrange for them to be hauled away by the same cart that delivers the fresh leaves.
In wet weather carts can bog down in the mud and leaves may need to be packed into sacks and hauled to the road on workers’ shoulders. Wider tires such as automobile tires don’t bog as easily as bicycle tires, but they add a lot more weight and friction to the load. Motorcycle tires may be a good compromise in areas where inexpensive used ones are available.

Transportation of leaves is one of the most commonly underestimated expenses in leaf concentrate projects, and it is well worth giving some thought to this at the initial planning stage.

**Weighing Leaves**

After the leaves are brought into the workshop they should be weighed. The leaves can be weighed with a bathroom scale, a fishhook type scale, or a scale used for weighing grain and feed. Weighing leaves and recording the weight every day may seem like an unnecessary bother, but it provides projects with important information. If the leaves and the leaf concentrate are weighed every day it becomes possible to analyze labor costs, processing efficiency and other aspects of production critical to an economically healthy program.

If you are buying leaves, it is normally better to buy them by weight than volume as it relates more directly to yield. Don’t pay extra for leaves that a farmer has hosed down, as the water will not yield any LC. By correlating leaf weight with LC weight, you may be able to see that a certain type of leaf crop is more economical, or that leaves from one farmer are a better buy than those from another. Changes in the ratio of LC produced to the weight of the leaves may alert you to problems with machinery, processing, or agricultural technique.

**2. Wash the leaves**
Once weighed, the leaves should be inspected for pieces of stick, roots, and rock. It is usually not necessary to remove weeds, grass, or dead leaves. Only when there are a lot of weeds known to be poisonous or very bitter tasting is it worth the trouble of picking out every one. In several projects the extremely careful picking out of stray weeds and bits of grass was taking more time than grinding and pressing the leaves, and providing no benefit.

After inspection the leaves should be immersed in clean water to remove dirt and dust. This can be done in large washtubs or in specially designed wash tanks. Small amounts of leaves can be washed by hand then shaken out to remove excess water before cutting and grinding. For larger quantities of leaves you will probably want to use a special tank and handle the leaves with clean pitchforks or rakes. In either case you want to remove the leaves from the tank rather than drain the water and then remove the leaves. When the water is drained much of the dirt gets caught in the leaves on its way out. If you can't grind the leaves right away for any reason, try to leave them in the wash tank, as this will delay wilting which lowers leaf concentrate yield.

Where water is in short supply you may want to use this water at least once more. It can be used for the initial rising out of pots, filter cloth and processing equipment. Ideally it could then be used to water crops. If a crop field, orchard or garden is downhill from the processing site it may be worth running a tube or a ditch to carry this wash water to plants. It is important that the wash water not be repeatedly drained very near the workshop or the soil will quickly become waterlogged and foul smells will follow. It could also become a breeding ground for mosquitoes that can spread malaria, dengue fever and other diseases in tropical areas.

3. **Cut or tear the leaves into pieces**

Depending on the crop and the type of pulping equipment used, it may be necessary to cut or tear the leaves into smaller pieces before pulping them. This step reduces the work that the pulper must do and may eliminate long fibers wrapping around machine parts. Pre-cutting leaves also makes feeding the crop into leaf pulpers easier. Vine crops especially are difficult to feed into leaf pulpers if they are not cut to shorter length first. Some tropical legumes have vines several meters long that tend to get very tangled.
Precutting the leaf crop can be done with a forage chopper. These can be treadle powered, bicycle powered or motor driven. Relatively small amounts of leaves (up to about 200 kg can be cut on a table with a machete or cutlass. This is tiring work, and the likelihood of accidents increases as people become fatigued from heavy exertion. Very small quantities of leaves can be stripped from their vines by hand. This is very slow, but worthwhile on a domestic scale where leaves are pulped with manually operated equipment.

Precutting leaves adds a time and energy-consuming step to the leaf concentrate process. This step often takes longer than pulping. It may also require additional machinery, such as forage choppers. Whenever possible it is advantageous to avoid this step. The impact macerator is a leaf-pulping machine that can handle fairly long fibrous leaf stems (alfalfa up to 70 cm [28”]) without precutting. This is one of the main reasons we are currently advocating use of the impact macerator for small leaf concentrate programs.

4. Grind the leaves to a pulp.

Perhaps the most critical aspect of economic leaf concentrate production is the pulping of the fresh leaves. In order for juice to be squeezed easily from the leaves they must be well ground. There are a number of ways to do this, several of which will be briefly described in this section. However one goes about pulping the leaves, the object is to break open as many of the leaf’s fibrous cell walls as possible. When these walls are broken open the nutrient rich contents of the cells can pass into the juice and later be recovered as curd.

When leaves wilt, the pressure inside the cells is reduced and the amount of force required before rupturing the cell wall increases; just as it is easier to pop a fully inflated balloon. The yield of LC from most crops will decline 4-15% in 4 hours and by 50% after 9 hours. Even with ideal circumstances, it is impossible to rupture all the cell walls, but some techniques work far better than others. If clearly recognizable pieces of leaf remain after pulping, cell rupture is inadequate.

Generally smashing leaves works better than cutting them repeatedly. Pulping the leaves takes several times more energy than pressing the juice out. It is usually uneconomical in terms of energy to try to squeeze juice from leaves that have not been ground up first.

Several studies on industrial scale leaf fractionation have shown extrusion, or the driving of leaf crop through small openings, to be the most energy efficient means of rupturing leaf cells. Smaller scale extruders have not performed as well. Probably extrusion is superior to other methods of cell rupture only when over one ton per hour of leaves is being processed. On the other extreme leaf crop can be pulped with hand operated grinders. We do not normally recommend this because it dooms the operator to a very low hourly productivity.

There is currently no off-the-shelf machine that is designed specifically to make leaf concentrate. There are some machines like hammer mills and meat grinders that can be
fairly easily adapted to the purpose. In choosing a machine to pulp leaves it is worth considering at least the following:

- **cost** and availability
- **throughput** (how many kilograms of leaves can be processed per hour)
- **clean up time** required (this can be a significant hidden labor cost)
- **dependability** and ease of maintenance (a 100 kg per hour machine that has a lot of down time may produce less per month than a more dependable 50 kg per hour machine.)
- **energy use** (what is the cost of energy per kg of LC produced? Does it use a form of energy readily available? 3 phase electric motors are generally more efficient than single phase, but only if 3 phase current is available where you are working)
- **safety** and noise level

A number of different leaf pulping machines have been tried in village programs. Some of these are discussed in the chapter on Other Leaf Concentrate Processing Equipment on page 149. Below is some information on the leaf-pulping machine that we currently recommend using in projects that process over 100 kg and less than 1000 kg of leaf crop per day. Drawings are on page 175

### The Impact Macerator

The main pulper that we use is a modification of a tool developed at the University of Wisconsin in the US by Richard Koegel and Hjalmar Bruhn. It is basically a vertical axis hammermill with a single fixed hammer. Leaves are dropped into a large feed hopper that directs them to the center of the blades. They spin at approximately 3450 RPM inside a 350 mm (14")* cylinder made of steel or very heavy gauge PVC. (*Measurements are mostly approximate metric equivalents of work done in the English system). The leaves are smashed by the blunt blades and fall through to a 58 X 35 cm (23 " X 14") plastic washtub sitting below the cylinder. The cylinder sits on a frame of 50 mm (2") square steel tube. A two horsepower high-speed motor is mounted vertically between the legs of the frame.
In the original design the macerator was driven directly from the motor shaft. Driving the macerator with a pulley instead allows the placement of the motor outside the cylinder so that only the belts and pulleys need to be covered. It also allows for the macerator to use a greater variety of motors that may be less expensive, and to use gasoline or diesel motors where electricity is not available. A pulley driven macerator has to have bearings on the shaft the blades are attached to and some means of preventing pulp from piling up on the belt shroud. One advantage of the direct drive is that the motor bearings are the only ones needed. It is quite possible that the motor bearings would last longer, however, if the shaft had its own set of bearings. In addition we can use nickel-plated food grade top bearing, which makes for a more hygienic process. The external powered macerator is quite a bit quieter.

The power is transferred from the motor by way of a set of pulleys and a fan belt to a 250 mm (1") stainless steel shaft. The shaft passes through two bearings separated by about 125 mm (5") of steel support. The top bearing is of sealed nickel-plated food grade materials since it comes in contact with the leaf crop. About 95 mm (3 3/4 ") above the top bearing a blade is mounted on a stainless steel hub that is fixed to the shaft with 2 Allen screws set at 90° from each other.

The blunt blades or hammers are a cross of high density nylon (Nylamid) 37.5 mm wide X 12.5 thick mm X 338 mm long; (1 1/2", 1/2", and 13 1/2"). The hitting surface of the blades is covered with stainless steel of 16 gauge. This cover is bolted through the top of the blade with 6.25 mm (1/4") stainless steel bolts with lock or pressure washers. The stainless steel cover gives much greater abrasion resistance to the blades without the weight of solid stainless steel blades.

The PVC cylinder sits on the very inside edge of the frame, and is held in place by four 4" angles extending from the corners of the frame. Two 7.75 mm (5/16") bolts with wing nuts prevented the cylinder from vibrating. We use a cylindrical galvanized sheet metal feed hopper. It is a 425 mm (17") in diameter, and 400 mm (16") high; with a shallow cone attached that ends with an 200 mm (8") opening about 100 mm (4") over the center of the blades.

It is necessary to pass the leaves through the macerator twice in order to achieve adequate cell rupture. Tests in Mexico using alfalfa indicate that with two passes the macerator grinds the leaves about as well as a 5 gallon liquidizer, and it does so in considerably less time. The macerator doesn't require precutting the leaf crop, a time consuming step that is necessary with many small-scale leaf pulpers. Alfalfa 70 cm (28") long passed through without problem. The macerator also eliminates the handling of liquid that is necessary with the 5-gallon liquidizer.

This macerator can pulp over 100 kg of leaves per hour even with two passes. A bit of experience is needed before workers can match the flow of leaf crop into the macerator with the machine's capacity for maximum throughput. This is especially true on the
second pass where big clumps of pulp can overload the motor. A third pass improved the yield of LC further, but is probably justified only where leaf crop is very expensive.

We are still testing this machine and it is quite likely that the exact configuration of the blades, blade speed, cylinder size, feed hopper, and motor capacity that we recommend will be adjusted as we learn more about this machine. However, a few patterns emerged that were quite consistent. Adding water to the pulp always improved yield, though it doubled cooking time and fuel consumption. This is a technique where water equivalent to ½ of the volume of the leaf pulp is mixed with the pulp and allowed to sit for about ten minutes before pressing. The higher the blade speed and the slower the feed rate, the higher the yield was. Very high blade speeds led to unacceptable vibration and noise.

5. Press as much juice as possible from the pulped leaves

After the fresh leaves are ground up or pulped, the juice must be separated from the indigestible fiber. This is usually accomplished by pushing the pulp against a fine screen or a filter cloth that allows most of the juice to pass through but holds back the pieces of fiber. A thin layer of pulp (less than 4 cm [1½"] works far better than a thicker layer. When a thicker layer of pulp is pressed, much of the juice from the center of the layer tends to be reabsorbed by the drier pulp at the edge of the layer. Some of the large protein molecules are also filtered out when the leaf juice must pass through a thick layer of compacted pulp to escape. This lowers the yield of leaf concentrate. Very high pressure is unnecessary and can complicate things by clogging filters. A pressure of 2 kg per cm² (30 lb. per inch²) applied over a layer of leaf pulp that is initially 2.5 cm (1") thick for ten seconds is usually adequate. Pressures as low as one third of this can be effective if the pulp is reoriented and pressed a second time. After pressing, it should not be possible to get more than a drop or two of liquid from the fiber when it is squeezed in your fist.

Below is some information on the juice press that we currently recommend using in projects that process between 100 kg and less than 500 kg of leaf crop per day. Some of the other machines that have been used to press leaf juice are described in the section on other processing equipment, page 153. Drawings of several of the presses described are in the appendix.

The Hydraulic Jack Press Table

The hydraulic jack press table works by spreading a layer of pulped leaves over 60 X 60 cm (24" X 24") surface, 3-5 cm (1-2") deep and applying pressure over that area with a 12 - 20 ton hydraulic truck jack. After the juice is pressed out, the jack and the wooden press plate it sits on are returned to their original position with 2 stout springs. It is worth trying to get the jack set for the minimum return that will allow the pulped leaves to slide underneath. This will reduce the time consuming effort of using the jack handle to bring
the press plate into contact with the leaf pulp. The press plate should be covered with thin stainless steel or galvanized sheet metal.

A table is built with 2" thick wood under a galvanized tray that has 2 - 4 layers of rabbit cage wire fence or some plastic fencing material on top to allow the leaf juice to run off freely. It is worth having a good jack that can be easily rebuilt. Enerjac, Hein-Werner, and Lincoln make professional quality 12-ton bottle jacks that are available in the US. Jacks may need to have air bled out of them every three months. Most jacks have a rubber nipple that can be removed for this purpose.

The galvanized tray is large enough to hold two 60 X 60 cm (24" X 24") wooden frames that have 62 mm (1/4") woven wire mesh (hardware cloth) fixed to their bottom side. This allows the press operator to fill one tray while the other is being pressed. The tray needs to be inclined enough for the juice to flow freely into a bucket.

The complete press table cost about $350-400 US built in Mexico. With a little practice it does a good job pressing loads of 6 kg of leaves. It has a capacity of about 50 - 75 kg per hour. For projects processing over 200 kg of leaf per day a motorized version of this press, described on page 155 may be more appropriate.

### Strain the Leaf Juice

The leaf juice should be strained through a screen or cloth before heating to remove particles of fiber. If a significant amount of fiber is left in the leaf juice the appearance and the nutritional composition of the concentrate will be somewhat altered. Small amounts of fiber are usually not a problem in the diets of adults. For children in developing countries whose diet is already high in fiber, however, fiber can aggravate diarrhea and make some nutrients more difficult to absorb.

### 6. Heat the juice rapidly to the boiling point.

Leaf concentrate is separated from the leaf juice by coagulating the protein. When the protein coagulates many other nutrients are pulled together in this curd. The most effective way to coagulate the protein in leaf juice is to heat it rapidly. While the leaf curd or concentrate will form by the time the leaf juice reaches 65° C (147° F), it is very
important to continue heating the juice to the boiling point. This serves several purposes, including:

- **pasteurization** of the leaf concentrate to kill most harmful microorganisms that may have been on the leaves from the soil or from handling.
- **destruction of enzymes** in leaf juice that can lead to off flavors, and more rapid deterioration of the concentrate, as well as to the formation of pheophorbides. These substances can cause sensitivity to light and allergic reactions in some people.

- **formation of a firmer curd** that is much easier to separate from the leaf juice than the soft curd that forms in juice that is not heated to boiling.

Heating should be as rapid as possible. Heating slowly will cause a reduction in yield. It also causes the curd to be soft and fine textured. This type of curd is undesirable because it seals up filter cloths that are used to separate the curd from the remaining liquid ("whey"). Slow heating also results in greater fuel costs, as more heat is lost to the air. It is not necessary to keep the leaf juice at a boiling temperature. Holding the juice at the boiling point for more than a few seconds will cause some loss of vitamins as well as greater fuel costs, without providing any benefits.

The simplest way to heat leaf juice, and the method we use most often in small projects, is to put it in a large shallow pan over a hot flame. This is a very familiar process to peasant women who generally bring liquids to a boil over fires several times a week. The pot should have a top to conserve heat.

Heavy gauge stainless steel is the best material for the cook pots to be made from in terms of cleaning and not contaminating the juice. Aluminum pots are generally much cheaper and more readily available than stainless steel. Light gauge pots of any material should be avoided because there will be more problems with curd burning on the bottom of the pot. Burning of curd can be greatly reduced by gently scraping across the bottom of the cook pot a few times just before the juice reaches the boiling point. It may be helpful to use the same amount of juice each time you heat so that you can time how long it takes to come to a boil. For example in Mexico we have been heating about 18 liters in a 30-liter pot. It takes about 13 minutes to come to a boil using a high-pressure gas burner. We can use an inexpensive kitchen timer set at 11 minutes so that we don't have to constantly watch the pot. When the timer buzzes someone will take off the lid and begin gently scraping the bottom of the pot. This prevents boiling over, and reduces burning curd and unnecessary fuel use.
Gas fires are sometimes not hot enough for efficient curd formation. This may be due to a regulator keeping the pressure too low or to low quality gas. A local person experienced in gas fittings should be consulted to make sure the fittings, hose and burners are all compatible with high pressure gas. Heating time can sometimes be shortened and fuel use lowered by protecting the flame from breezes with a metal skirt. This is especially true if heating is being done in a partially open workshop. It is important to make sure the flame is well distributed over the bottom of the pot, not concentrated in one small circle. Raising or lowering the pot relative to the flame can insure that the maximum heat is reaching the cook pot. If the gas flame is yellow the air intake setting needs to be adjusted for more efficient burning.

Wood fires frequently burn at too low a temperature for good coagulation of leaf juice. If you are using wood fires and the juice is taking a long time to come to a boil or the curd is very soft and fine textured, the flame may not be hot enough. The heat of wood fires can often be increased by:
- using drier wood
- splitting the wood into smaller pieces
- increasing the air flow through the combustion area. This can be done by enlarging the air opening or by using a small fan to bring air to the fire.

Whenever the heating of the leaf juice is done inside it is important that the room be well ventilated. Smoke and carbon monoxide can build up from burning in an enclosed area. Wood stoves need to have a vent pipe or chimney of some type to draw the smoke out of the room.

Two other techniques have been employed in heating leaf juice. These are steam injection and trickling the leaf juice into water held near the boiling point. Steam injection is used on larger scale operations such as the France Lucerne plant that handles many tons of alfalfa per hour. It is probably not worthwhile on village scale operations. Some workers for small-scale leaf concentrate production have advocated trickling juice into a pot of water.

The idea is to trickle leaf juice in at a rate that will never lower the water temperature below 80° C. A curd forms almost immediately and floats to the surface. It can then be floated down an overflow into a container below. The advantages of this system over heating in a pot are that it is continuous and that the curd never burns because it doesn't stay in contact with the bottom of the pan. The drawbacks are that it is more difficult to arrange and coordinate and that the juice is not heated as conclusively to the boiling point, thus pasteurization is not as thorough.

Curd can be obtained from leaf juice without using heat in a number of ways. These include centrifuging, ultra-filtration, fermentation, and acidification. None of these techniques appears to be superior to heat except in specific laboratory circumstances. In village leaf concentrate program heat is clearly the preferred way to coagulate leaf juice.
7. **Separate the curd that forms in the heated juice in a tightly woven cloth.**

After the leaf juice reaches the boiling point it should be removed from the heat and allowed to stand for a few minutes to cool. Leaving the curd a few minutes in the hot liquid assures better pasteurization with no further fuel costs. Letting the liquid cool a bit before separating the curd reduces the chances of workers being scalded from hot liquid. The cook pot should never be filled completely, especially if it is going to be moved while there is hot liquid in it. If the quantity of juice heated at one time is fairly small (under 20 liters) it can be handled by two workers pouring the entire contents of the cook pot through a filter cloth of tergel type material. This cloth can be supported by a 60 X 60 cm (2' X 2') wooden frame that has 62mm (1/4") woven wire mesh (hardware cloth) fixed to its bottom side. This can be identical to, and serve as a backup for the tray used in the hydraulic jack press. This frame can be set on a washtub so that the "whey" will pass through the cloth and be collected in the tub. The relatively large surface area and open weave of the cloth will allow the "whey" to drain freely from the curd. The curd is then placed in a more tightly woven cloth, like the cotton-polyester twill below, and pressed to remove as much "whey" as possible.

If more than 20 liters of leaf juice is being heated at a time it will be necessary to use a custom built cook pot with a valve that can allow the "whey" to be drained off after the curd is scooped out. It has been easier for us to use rectangular than round pots for larger quantities of liquid.

A rectangular scoop similar to those used for removing foods from deep fryer can be used to remove the curd. It should be covered with a metal screening material about as finely woven as normal insect screen. The scoop can be made to barely fit inside the narrow dimension of the cook pot, so that almost all the curd can be removed by dragging the scoop the length of the pot then raising it. You may want two handles rather than one for easier handling. You can arrange for the scoop to drain for a few minutes above the cook pot after the curd has been removed. This type of arrangement is common for draining grease from deep fried foods. The valve for this type of a cook pot must be at least one inch in diameter and easy to clean. The curd from the scoop can be then put into the twill type cloth for thorough pressing.

By far the easiest way we have found to press the "whey" from the curd is to spread it in a layer not more than 2.5 cm (1") deep on the twill cloth and press it in the hydraulic press table. The process is the same as the pressing of the juice from the fiber except that twill is used instead of tergel cloth and the pressure must be applied a bit slower and held for a bit longer. After being pressed the curd should be crumbly and contain about 60% moisture.

8. **What remains in the cloth is LEAF CONCENTRATE**
Filter Cloth

Pressing the juice from the pulped leaves and pressing the "whey" from the curd require a mesh or filter of some type to keep the solids on one side and allow the liquids to pass through. We have found cloth to be the cheapest and easiest way to do this. We generally use a synthetic cloth like polyester Tergel for separating juice from leaf pulp and finely woven cotton - polyester blend twill for separating "whey" from curd. The Tergel also works for the initial straining of curd from "whey" and for drying trays.

PRESERVING LEAF CONCENTRATE

Washing the Curd

Washing leaf concentrate is sometimes recommended as a means of reducing strong flavors and slowing down the growth of molds. Often a strong unpleasant flavor in leaf curd is due to soluble compounds that have not been adequately pressed out. To wash fresh LC it should well mixed in ten times its volume of clean water. It is next stirred well and allowed to stand for 10-15 minutes. It is then separated and pressed in exactly the same way, as it was when the curd was separated from the heated leaf juice. The stability of the curd may be improved by adding 5% salt to the water used to wash the curd or by adding enough acid to lower the water pH to around 4. Washing adds an additional step in the process, plus the expense of salt or acid if they are used. It also can reduce the B vitamins that are available in the curd. Where strong flavors are not a problem and the leaf curd is used or preserved soon after being made, this step is usually not recommended. If you are having trouble with strong flavored curd or rapid molding, try washing the curd.

Why Preserve Curd?

There are numerous reasons for wanting to preserve leaf concentrate. In most locations production of leaf crop is greater at some times of the year than others. In the tropics there is often a wet season with good leaf production and a dry season with poor leaf growth. In cooler climates there is frequently a season when cold weather severely limits leaf growth. Preserving leaf concentrate from the periods of maximum growth allows you to continue with child feeding programs or sales of products throughout the off-season. Sometimes you may want to use preserved leaf concentrate when repairs are being made on machinery, changes being made at the workshop, or workers unable to work for whatever reason. Having some preserved leaf concentrate on hand is good insurance against such short term problems as running out of gas or the electric being out for a couple of days. If your program can continue to deliver leaf concentrate despite
these inevitable problems, people who may have been suspicious of the program's value, will often come to respect your dependability. Where several small nutrition intervention programs are linked, it may make economic sense to produce all the concentrate at the site with the best conditions and to distribute preserved LC from there to the other sites. This will often mean lower costs for feeding programs than running several very small LC production sites using fresh leaf curd.

**How To Preserve Leaf Curd**

Fortunately, there are easy ways to preserve leaf concentrate. A few basic principles apply to all of these methods. The leaf concentrate should be preserved as soon as possible after it is made because bacterial action will begin quickly. Remember that the rich nutrient content that makes leaf concentrate so beneficial for humans also promotes rapid growth of many microorganisms. Leaf concentrate should be stored in a container that is as airtight as possible, and it should always be stored in a location that is cool, dry, and out of direct sunlight.

A system of marking the dates that the leaf concentrate was preserved will help you to rotate your stock. This way you will use older leaf concentrate first and avoid having some go to waste because it is stored for too long. How long it can be stored is not an exact science. It will depend on the methods used and the percentage of moisture in the curd, as well as the condition in which it is stored.

No matter how long leaf concentrate has been stored it is a good idea to smell it and examine it closely before using it. If it smells of rotted vegetation or has any visible signs of mold on it don't use it.

Below are some easy formulas for preserving leaf concentrate that are possible without expensive equipment. For each kilogram of fresh leaf concentrate (at 60% moisture) you wish to preserve, mix with:

2 kg sugar + 1 liter lemon juice
(blend leaf curd and juice together at high speed then add sugar to make a lemonade syrup that will keep)

OR

2 kg sugar + 1 liter water
+ 40 grams salt
(salt helps preserve LC and reduces settling when syrup is mixed with water)
OR

2 kg sugar + 1 liter water + 40 grams salt
(salt helps preserve LC and reduces settling when syrup is mixed with water)

OR

2 kg sugar + 1 liter water + 40 grams salt + 1600 mg vitamin C
(This is a syrup formula we've used successfully in Nicaragua. Vitamin C, or ascorbic acid, is an antioxidant that helps preserve LC; it also makes the iron in LC easier for the body to utilize. This will provide about 25 mg vitamin C per 15 grams of LC)

OR

2 kg sugar
(to make a paste that can be added to many sweet foods and drinks.)

The rule of thumb: for each kg of water you need 3 kgs of sugar. So 1 kg of LC at 60% moisture contains 600 grams of water and needs to have 1800 grams of sugar added to preserve it

OR

200 grams salt
(This can be mixed and stored in airtight plastic bag, or layered and store in brine like sauerkraut. The salt needs to be washed off before it is eaten). It is important to note that while salt can be a fairly easy and inexpensive means of preserving leaf concentrate, that much of the beta-carotene can be destroyed if the mixture of LC and salt is exposed to air for any length of time. The very thin polyethylene bags available in many developing countries are generally not an adequate barrier for keeping out air. Heavier plastic bags (1.75 mil and thicker) will work better but are much more expensive, and not widely available. The beta-carotene is important because it is converted to vitamin A in the body.

OR

50 grams pure acetic or propionic acid
(these are harder to find and handle and usually more expensive)
2-4 kg wheat, corn, millet or rice flour

(then dry to less than 10% moisture)

OR

Leaf concentrate can be dried alone

Drying LC has been a discouraging business and we have not encouraged some projects to work in that direction. In much of the tropics peak leaf yields coincide with very wet weather, which makes drying in outdoor trays very difficult. Drying leaf concentrate can be tricky. The drawbacks of drying are that it tends to case harden, so there are particles of leaf concentrate that are very dry on the outside but still moist on the inside. These appear to be dry but can gradually wick moisture to the surface and mold in storage. Dried leaf concentrate can be a difficult food to work into recipes. It is often like adding sand into foods. If it is dried at too high a temperature the protein quality can be damaged. If it is dried too slowly, there is more chance of bacterial contamination or mold. It can turn an unappealing greenish black color when dried, and a grassy flavor can become stronger.

On the positive side, it is possible to make a good quality dried leaf concentrate with an inexpensive drying setup and a little extra care. There are a few things that make successful drying of leaf concentrate much easier. The most important is starting with very well pressed curd. Leaf curd that is well pressed in a closely woven cloth should be crumbly. If you can take a pinch of leaf concentrate and smear it on the palm of your hand like finger paint it is not well enough pressed. It should roll up and leave your hand clean. Well-pressed curd will dry more quickly with less case hardening than wetter curd.

Granulating the Pressed Curd

One of the important factors in drying LC is how finely broken up it is beforehand. We had some problem with case hardening and mold in Nicaragua. We were just crumbling up the curd in our hands and some of the particles were larger than others. Granulating the LC by pushing it through an insect screen gives a uniform finely divided curd that grinds up easily when dried. The screen needs to be backed by hardware cloth or some kind of stronger wire mesh or the screen will pull loose from rubbing the curd through it. It is a fairly time consuming process that would need to be modified for 10-25 kg per day LC production. Pushing the curd through 1/4” hardware cloth is very fast but leaves pieces of curd large enough for case hardening. Passing the curd into a 5 gallon blender twice for a few seconds each time, breaks most of the curd up as finely as granulating, but a few bigger pieces need to be sifted out and re-
blended. Workers at the University of Wisconsin reported better drying rates when the curd is driven through 3/16" holes in a dieplate on a meat grinder before drying. We have not tried this technique yet. It may be useful when drying curd that is quite moist (70% moisture) or when more than a thin layer is put on a tray or rack.

We tried granulating the curd with the macerator as well. It required two passes and we needed a plastic skirt to prevent the granulated curd from bouncing and blowing out of the washtub below the macerator. It was dramatically faster and easier than the manual granulator. The curd needs to be well pressed for this to work. In Mexico, we are recommending that the curd from the previous day be granulated in the macerator first thing in the morning when the machine is clean and dry, and then the maximum sunshine would be available for drying during the day.

There are many different types of food dryers that could be used to dry leaf concentrate. Described below are the simplest, least expensive ones that we've had success with in Mexico and Nicaragua. Some other types of food dryers are described in the chapter on "Other Leaf Concentrate Processing Equipment".

**Tray or Rack Dryers**

We have been using large trays or racks covered with finely woven synthetic fiber for drying LC in a few locations. Cloth such as nylon curtain material that is open enough to allow the passage of air is ideal for making drying racks. The dried curd comes off synthetic cloth more cleanly than it does from cotton. This cloth can be stretched tightly over wooden frames. The corners of the frames should be braced to maintain rigidity. The leaf concentrate is spread in a thin even layer on the frames at a rate of one to two kilograms per square meter (1/4 - 1/2 pound per square foot). Trays of under 1 meter (39 X 39") on each side can be loaded, moved and emptied fairly easily by a single person. Our larger trays 180 X 85 cm (72 X 34") were difficult to handle. The worst trays were this size with a cross brace across the middle that made them almost impossible to empty without spilling some of the dried LC.

**Simple Solar**

The simplest way to use these racks is to put them outside where the sun shines all day. They can be set up on bricks or blocks to allow the free movement of air underneath. It is essential that the racks be covered in such a way that the heat from the sun reaches the drying curd but the light from the sun does not. Direct sunlight will quickly destroy the beta-carotene (pro-vitamin A) in leaf concentrate. It is possible to stack drying racks on top of each other in such a way that each provides shading for rack below. Then only the top rack needs a cover. Of course, this gives the trays less exposure to the sun's heat than if they are spread out only one tray deep. Tightly woven black cotton cloth works well for blocking the ultraviolet rays while absorbing the solar heat.
A somewhat more expensive dryer can be built in place. A light wooden frame box roughly 2 meters X 2 meters (c. 78 X 78") is inclined from c. 50 cm to 20 cm (20 to 8") to shed water. It is covered with 4 mil clear polyethylene supported with wire poultry netting. Trays with granulated leaf concentrate spread at approximately 2 kg per m² (c. ½ lb per square foot) were slid into frames about 10 cm (4") below the polyethylene. The same trays were used but they were covered with black cotton cloth to protect the leaf curd from sunlight. The sides had removable sheet metal panels that allowed the trays to be slid in or out. It was not airtight and the only airflow was what came through small incidental openings in the box.

This was a very effective dryer. It quickly reached temperatures of 50 -55°C. In a comparison test we dried 2 kg per meter ² granulated LC (64% moisture) for 2½ hours at 28° C air temperature on each of the dryers. On this dryer the LC was 13% moisture after 2½ hours. Ultraviolet resistant polyethylene film would be good as the more common film that we used photo degrades in less than one year. UV resistant film would probably have to be imported.

We used the same principle of letting the sun pass through the clear plastic film to heat up black cotton cloth stretched over the curd, but in a much simpler and cheaper arrangement. Plastic film was attached to one side of a wooden frame 180 X 85 cm (72 X 34") and black cloth stretched across the other side. This frame was simply placed over a drying tray (which was made with fine weave tergel polyester cloth) loaded with granulated LC and supported by bricks at the corners. After 2½ hours the LC was 21% moisture. It heated up to 40 - 45°. The airflow below the drying tray was significantly greater than in the box and may have been partly responsible for the lower temperatures and slower drying. These frames are simple, cheap, and mobile, and stackable.

**Grinding and Storing Dried Leaf Concentrate**

For leaf concentrate to store well it should be dried to less than 10% moisture then sealed in an airtight container out of sunlight. Thin plastic bags will allow too much oxygen to pass through to the dried curd. Without a moisture meter it is somewhat difficult to tell if your concentrate is dry enough. You can do a rough moisture test on a small amount by putting 100 grams of the air dried concentrate in a very low oven (100° C [220° F]) for 12 hours and weighing the difference. For rough tests I dry a sample until it seems to be very dry then weigh it. Then I dry it for another 15 minutes and put it back on the
balance. If there is no measurable difference in weight, this can be considered to be the dry weight. You will need a fairly accurate gram balance to do this.

The dried leaf concentrate is far easier to use later if you can grind it to a very fine powder. It will have a lighter green color and incorporate much better in recipes if it is ground nearly as fine as flour. Dried LC that is not ground very finely will leaves foods with an unpleasant gritty texture. The high protein content of LC makes for very hard particles when it is dried. If dried LC is not ground very finely some of it may pass through the body as particles without being fully digested and absorbed. So fine grinding will also make it easier for the body to utilize the nutrients in dried leaf concentrate.

You may need to sift it through a fine cloth to make sure it is all finely ground. We have found that it is difficult to grind dried LC finely enough with the inexpensive hand operated flour mills available in many developing countries. Commercial grinders are reluctant to grind LC because some of it will remain in the mill and give flour a greenish hue for a while. The most effective tool I have found for grinding dried LC is an electric mill with stainless steel heads made in the US. It is called MagicMill and retails for about $240 US. Their address is in the resource section in the rear of this manual. Be sure to specify whether you want a 60 HZ (US and Central America) or 50 HZ (most of the rest of the world) motor. They are very loud and quite slow. These mills will grind a kilogram of dried LC in about 20 minutes. However you grind dried LC, try to avoid breathing the fine green dust that is made in the process. Putting the grinder inside a plastic washtub with a wooden top and a cloth airvent made the grinder far quieter and eliminated the dust problem. We are still looking for a better solution to the problem of grinding dried LC.

Finely ground dried LC works well in most recipes. Generally if you use one third as much dried LC as fresh and add two parts of water you have approximated the fresh LC. So that 1 kg dried LC plus 2 liters water is roughly equivalent to 3 kg fresh LC. Dried LC has not worked well in drink mixes. It settles too quickly even when finely ground. Most drinks are sweet enough so that sugar preservation of the fresh LC is a better option.
The Basics of Drying LC

1. Start with very well pressed curd (c. 60% moisture)

2. Granulate the curd to get small uniform sized particles and increase the ratio of surface area to weight

3. Expose the granulated curd to heat. 50°C [120°F] is ideal, 60°C [140°F] is the maximum

4. Expose the granulated curd to moving air to remove the moisture that evaporates from the surface of the LC

5. Dry the LC as quickly as possible after it is made

6. Protect the drying LC from sunlight, blowing dust, insects, and rodents

7. Dry to below 10% moisture. If you're not sure, finish drying it in an oven at a very low temperature

8. Grind as finely as possible

9. Store in thick, well sealed plastic bags, with as much air removed as possible; in a cool dark place
SECTION II

NUTRITION

People whose diet provides their body with a regular and adequate supply of the 40
nutrients essential for growth and health are said to be well-nourished. Those whose
diets fall short on one or more of these essential nutrients are malnourished. Malnutrition
is the biggest health problem in the world. The World Health Organization estimates that
730,000,000 children in the world are currently malnourished. In Mexico it is estimated
that 1 child in 3 is malnourished.

Malnourished children are smaller and weaker than their peers. They have more frequent
and more severe intestinal and respiratory infections, and they take longer to recover
from them. Their attention span is shorter and their ability to concentrate or remember
things is less than that of well nourished children. Their life expectancy is shorter. In
severe cases, they suffer permanent mental and physical damage in their first tender years
of life from a lack of enough food. In a world where the struggle to succeed can be very
tough, they begin life at a tremendous disadvantage, through no fault of their own.

The suffering and loss of human potential from malnutrition is unnecessary. Malnutrition
is preventable in much the same way that smallpox and polio are. While there is no
vaccine against malnutrition, the same creative forces that developed the vaccines and the
same determination that makes sure children are vaccinated against crippling diseases can
free our children from the plague of malnutrition. Leaf concentrate can be a powerful
tool in the effort to defeat malnutrition.

While a lack of any one of 40 essential nutrients can cause a specific deficiency disease,
malnutrition almost always involves an under supply of many nutrients, chief among
them:

- protein
- energy or calories
- iron
- vitamin A
- calcium
- iodine
- folic acid
- vitamin E

Lets take a closer look at these nutrients and the role they play in the human body, and at
what foods supply them best.
PROTEIN:

Proteins are the basic building blocks of life. They are needed daily to build and repair muscles, maintain healthy brain cells, and for a wide range of enzymes and hormones that are involved in everything from digestion to sexual response and emotions. Proteins are especially important to young children and pregnant and lactating mothers. Children under 14 months can suffer permanent mental retardation from an inadequate supply of protein. Proteins are also very important when recovering from an illness or injury. Other nutrients, especially vitamin A, will not be fully utilized if the diet doesn't have sufficient protein.

Below several common foods are grouped by how much protein they contain.

<table>
<thead>
<tr>
<th>Highest</th>
<th>High</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
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<tbody>
<tr>
<td>Soy</td>
<td>Leaf</td>
<td>Beans</td>
<td>Wheat</td>
<td>Cassava</td>
</tr>
<tr>
<td>Concentrate</td>
<td>Chicken</td>
<td>Milk</td>
<td>Corn</td>
<td>Plantains</td>
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<td></td>
<td>Fish</td>
<td></td>
<td>Rice</td>
<td>Potatoes</td>
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<td></td>
<td>Pork</td>
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<td>Millet</td>
<td>Sweet Potatoes</td>
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<td></td>
<td>Beef</td>
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<td>Yams</td>
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<td></td>
<td>Cheese</td>
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<td></td>
<td>Taro</td>
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<td></td>
<td>Eggs</td>
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<td>Fruit</td>
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</tbody>
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Not only is the amount of protein important to us, but also the quality of that protein. The form of protein in some foods like milk and eggs is in a form that is more useful to us than the protein in corn or beans. This means we need to eat more grams of protein from corn or beans to have the same benefit to the body as the protein from milk or eggs.
Below several common foods are grouped according to the quality of their protein.

<table>
<thead>
<tr>
<th>Highest</th>
<th>High</th>
<th>Good</th>
<th>Fair</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Eggs</td>
<td>Leaf Concentrate</td>
<td>Soy</td>
<td>Wheat</td>
<td>Corn</td>
</tr>
<tr>
<td>Milk</td>
<td>Meat Fish Seafood</td>
<td>Rice</td>
<td>Beans</td>
<td>Gelatin Peanuts</td>
</tr>
</tbody>
</table>

Generally speaking the protein from animal sources, i.e. meat, milk, or eggs, is of higher quality than the protein from plants, i.e. beans, grains, or vegetables. One can improve the quality of protein from plants by mixing them. For example, the traditional Mexican mixture of corn and beans has a higher quality protein than either corn or beans alone. The same is true with the traditional Indian meal of chapatis (wheat) and dahl (beans), or the Chinese rice and soybeans, or the African millet and cowpeas. The protein in leaf concentrate is an excellent complement to the protein found in corn, wheat, rice, or millet.

Many people think that it is necessary to eat meat to receive an adequate supply of protein. This is not true, as many studies of vegetarians have shown. People who eat very little meat or other animal products like milk, eggs, or cheese, need to eat more grams of protein and remember to mix them. Because meat ordinarily takes more land to produce than grains or beans or vegetables, meat price will continue to be too high for meat to play a major role in the diet of billions of people. Because of this it is very important that we learn more about using vegetable proteins wisely.

Diets that are extremely rich in protein, especially protein from meat, have been strongly linked to osteoporosis, a disease in which the bones becomes brittle from losing calcium through the urine. Osteoporosis is prevalent among post-menopausal women, as the female hormone estrogen, which protects the body’s calcium, is no longer produced in sufficient quantity. Excessive protein in the diet is rarely a problem among low-income groups in the developing world, as most protein sources are much more expensive than foods rich in carbohydrates.
ENERGY:

Calories are a way to measure the energy in foods that power all human activity. Starches and sugars are the most important sources of energy, followed by fats and oils, then by alcohol. Carbohydrates and proteins have an energy value of about 4 Calories per gram, while fats have about 9 Calories per gram. Fats are said to be denser in energy. Sometimes weaning foods and foods for young children are too bulky for the energy that they provide the child. A child will become full before he has eaten enough to meet his energy needs. Water and fiber take up room in a child's stomach but do not supply energy. Sometimes traditional coarse porridges will have too much water and fiber to be adequate weaning foods.

The energy density of these foods can be improved by adding a small amount of oil or fat. Vegetable oils are generally considered to be better for us than lard or other animal fats like butter. These animal fats contain a lot of saturated fats and cholesterol, which have been tied to hardening of the arteries and heart disease. Coconut oil is also sometimes avoided because it is chemically more like animal fats than oils pressed from soy, sesame, safflower, cottonseed, rape seed (canola) and olives. Palm oil, although rich in saturated fats has been found to act more like vegetable oils that are rich in mono-unsaturated fats, such as soy and cottonseed oil. There is more information on porridges as weaning foods in the recipe section of this manual.

Complex carbohydrates like corn, wheat, beans, potatoes or fruit are considered to be healthier than refined sugar as energy sources for people. This is because they contain a range of other nutrients and they burn more slowly, which delivers energy to the body at a more consistent rate. Foods high in refined sugars, for example soft drinks, are sometimes said to contain "empty Calories". In some parts of the developing world, like urban Mexico, refined carbohydrates are making up a rapidly growing percentage of the Calorie intake. When this happens a person will meet his Calorie requirement long before reaching recommended intakes for several other nutrients. He must then either over consume Calories to meet his other needs and become obese, or become deficient in one or more essential nutrients.

A child who is not getting enough Calories in his diet will typically sit quietly and be apathetic while other children play. His body is trying to conserve the limited supply of fuel for more essential activities like breathing and pumping blood. A child who is not getting enough Calories from carbohydrates, fats and oils will burn up valuable proteins for fuel. Fresh leaf concentrate has about the same number of calories as an equal weight of chicken or eggs, but because it is usually eaten in rather small portions, it is not an important source of Calories.
IRON:

Iron deficiency anemia is the most common nutritional disease in the world. Especially at risk are women of childbearing age, who need extra iron for menstruation, pregnancies, and lactation; and young children, who need extra iron for rapid growth. UNICEF estimates 50% of the children in developing countries (c.500 million children) and 60% of the pregnant women in these countries suffer from iron deficiency anemia. The World Health Organization considers young children with hemoglobin counts below 11.0 g/dl or older children and adults with values below 12.0 g/dl to be anemic. Whenever blood is lost, as with wounds, hookworm, malaria, internal bleeding as with ulcers, menstruation or childbirth, iron needs go up significantly.

The body needs iron to make hemoglobin, which enables our blood to carry oxygen to every part of our bodies. When the supply of iron is low we can't carry enough oxygen to our cells to burn the fuel efficiently. When this happens we feel tired. Anemic children are smaller and grow more slowly than those with normal hemoglobin levels. They have less energy for playing or learning. Their mental development may be retarded and their attention span reduced. Their immune response is depressed, which leaves them more vulnerable to infections.

When women are anemic during their pregnancies, as the majority in developing countries are, their babies are more likely to be born prematurely or underweight. A woman whose diet is marginal in iron intake who has children closely spaced will often suffer from severe anemia. This can make her lethargic and apathetic and less able to care for her children. These babies are born with low iron stores in their livers and often become very anemic themselves before they are old enough to absorb adequate iron from the food they eat. These families have a high risk of severe health problems and should be a top priority in leaf concentrate programs.

As with protein, we must consider both the quantity and the quality of iron in the diet. Much the same as protein, animal based foods tend to be richer in both the quantity and quality of iron than plant based foods. However, as is the case with protein, it is very possible to get an excellent supply of iron from plant sources if one has a little information on the subject. Almost all diets contain more iron than the body needs. The problem is that most of the iron is poorly absorbed. Some of the iron in meat, fish, and poultry (heme iron) is quite well utilized, but the iron in grains, beans, and vegetables, and the remaining iron in animal based foods (non-heme iron) is very poorly absorbed. Because meat production yields less food per hectare than
grains, beans, and vegetables; meat products are usually too expensive for poor families in developing countries to buy. As a result the women and young families in these families suffer from very high rates of iron deficiency.

A chart in the appendix summarizes a study of anemic children in Bolivia that were given six grams of dried leaf concentrate five days a week for five months. The leaf concentrate costs about 5 cents per serving or about 5 dollars per child for the entire time. The leaf concentrate is especially effective when combined with a source of vitamin C, such as citrus fruit.

Anemia in adults lowers productivity and capacity to do work. This, of course, affects their ability to earn an adequate income and increases the likelihood that their children will be malnourished. Increasingly we see that anemia is implicated in a vicious cycle of malnutrition and poverty. Reversing anemia is a sound investment. A study in Indonesia, reported in the American Journal of Clinical Nutrition, showed that an iron supplement to anemic workers improved productivity an average of 15-25%. This meant a return of $260 for each $1 spent on the supplements.

Below are some common foods grouped by iron content.

<table>
<thead>
<tr>
<th>Highest</th>
<th>High</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Concentrate</td>
<td>Beef</td>
<td>Fish</td>
<td>Corn</td>
<td>Rice</td>
</tr>
<tr>
<td>Liver</td>
<td>Pork</td>
<td>Chicken</td>
<td>Mangoes</td>
<td>Milk</td>
</tr>
<tr>
<td>Eggs</td>
<td>Greens</td>
<td>Beans</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Please note that milk, while an animal product, contains almost no iron.

In some areas certain products are enriched with iron. Flour, bread, macaroni, and baby formulas are often fortified with iron. Find out if any common foods are fortified where you live and if low-income families regularly eat these products.

The absorption of non-heme (plant) iron is even worse when a meal contains a lot of bran, the fibrous part of grains. Tannin, which is found in tea, also makes non-heme iron more difficult to absorb. Deficiencies of other nutrients can aggravate anemia. Most important of these are: Folic Acid, Protein, Vitamin A, Vitamin B-6, Riboflavin, Copper.
The presence of meat in a meal makes the non-heme iron much more usable; but as was pointed out earlier meat is usually too expensive to be eaten by the poor. Ascorbic acid or Vitamin C also makes non-heme iron more useful to the human body. The study from Bolivia shows this relationship. Basically, the absorption of non-heme iron is considered to be four times as great in a diet containing 90 grams of meat or 75 mg of Vitamin C, as in a diet with less than 30 grams of meat or 25 mg of Vitamin C.

This is a very important consideration. It is often easier, cheaper, and more effective to add vitamin C, than to add more iron to the diet. Roughly speaking, a woman consuming over 75 mg of vitamin C will need only 1/4 as much iron as a woman consuming less than 30 mg of vitamin C; if the iron is from non-animal sources. Unfortunately the vitamin C in leaf juice is destroyed when it is heated, so leaf concentrate contains very little of this vitamin. We can compensate for this, however, by adding lemon juice or other sources of vitamin C. Leaf concentrate lemonade is therefore an extremely useful food for women and children suffering from anemia. Other good sources of vitamin C are guavas, other citrus fruits, fresh tomatoes, dark green vegetables, and other fruits and fruit juices.
## Vitamin C Content of some Tropical Fruits

<table>
<thead>
<tr>
<th>Fruit</th>
<th>mgs. Vitamin C per 100 grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acerola</td>
<td>1,677</td>
</tr>
<tr>
<td>Guava</td>
<td>183</td>
</tr>
<tr>
<td>Orange Peel</td>
<td>136</td>
</tr>
<tr>
<td>Lemon Peel</td>
<td>129</td>
</tr>
<tr>
<td>Kiwi</td>
<td>98</td>
</tr>
<tr>
<td>Longans</td>
<td>81</td>
</tr>
<tr>
<td>Lemon (whole with peel)</td>
<td>77</td>
</tr>
<tr>
<td>Jujube</td>
<td>69</td>
</tr>
<tr>
<td>Papaya</td>
<td>61</td>
</tr>
<tr>
<td>Pummelo</td>
<td>61</td>
</tr>
<tr>
<td>Strawberry</td>
<td>56</td>
</tr>
<tr>
<td>Orange</td>
<td>53</td>
</tr>
<tr>
<td>Lemon (without peel)</td>
<td>53</td>
</tr>
<tr>
<td>Cantaloup</td>
<td>42</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>38</td>
</tr>
<tr>
<td>Kumquats</td>
<td>37</td>
</tr>
<tr>
<td>Mulberries</td>
<td>36</td>
</tr>
<tr>
<td>Tangarine</td>
<td>30</td>
</tr>
<tr>
<td>Passionfruit</td>
<td>30</td>
</tr>
<tr>
<td>Mangos*</td>
<td>27</td>
</tr>
<tr>
<td>Starfruit (Carambola)</td>
<td>21</td>
</tr>
<tr>
<td>Pineapple</td>
<td>15</td>
</tr>
<tr>
<td>Sapodillar (Manilkar zapota)</td>
<td>15</td>
</tr>
<tr>
<td>Prickly pear (Opuntia spp.)</td>
<td>14</td>
</tr>
<tr>
<td>Apricots</td>
<td>10</td>
</tr>
<tr>
<td>Grapes</td>
<td>10</td>
</tr>
<tr>
<td>Watermelon</td>
<td>10</td>
</tr>
<tr>
<td>Cooked Plaintains</td>
<td>10</td>
</tr>
<tr>
<td>Bananas</td>
<td>9</td>
</tr>
<tr>
<td>Tamarinds</td>
<td>4</td>
</tr>
</tbody>
</table>

* Mangoes are considerably richer in vitamin C when slightly unripe.

Some vegetables are also good sources of vitamin C. For example, 100 grams of fresh kale contains about as much vitamin C as an equal weight of guavas. Part of the vitamin C is lost when vegetables are cooked. A study of leafy vegetables in Sri Lanka showed that on average the vegetables lost 32% of their vitamin C in five minutes of boiling and 54% in ten minutes. Steaming resulted in losses of 15% in five minutes and 39% in ten.
Small amounts of meat, especially organ meats, also help the body to absorb iron from non-animal sources. To be effective the vitamin C or meat must be eaten in the same meal as the iron source. The small amount of iron that enters our food from steel or iron food processing equipment is generally beneficial. A small amount of rust from iron cook pots may also be somewhat beneficial where iron deficiency anemia is prevalent.

Recent studies from Scandinavia have indicated that high levels of iron, especially in adult men may be a factor in heart disease. Men who are heavy meat eaters are more likely to be at risk. These studies will need further confirmation before they are used for general dietary recommendations.

VITAMIN A:

Vitamin A is essential for good vision and for the body's protection against disease organisms. People with low vitamin A intakes are more susceptible to several forms of cancer. Vitamin A is essential to the health of the mucous membranes that line the digestive and respiratory systems. This is the body's first line of defense against infection. Studies in Indonesia have shown children with low levels of vitamin A to be about 4 times as likely to suffer from diarrhea and respiratory infections as are children with adequate vitamin A levels.

The classic symptom of serious vitamin A deficiency is night blindness. Any children that have trouble seeing toys at dusk are probably somewhat deficient in vitamin A, and should receive immediate vitamin A in some form. About 500,000 children under 5 years of age go permanently blind from vitamin A deficiency in the world each year. Most of these children die from infections within a few years of going blind. Leaf concentrate, even in very small amounts, is extremely effective in combating vitamin A deficiency.

Actually, the vitamin A from plant sources is in the form of beta-carotene, which is converted in our bodies to vitamin A. Vitamin A is stored in our livers so we don't need to eat it every day. Food scientists have come to believe that the amount of vitamin A the human body requires for optimum health is much greater than it was previously thought to be. The new US Recommended Dietary Allowances have thus been greatly increased. Leaf concentrate is so rich in beta-carotene that only 10 grams will meet the new higher USRDA for vitamin A in a 4-6 year old child.
Some foods are grouped below according to their content of vitamin A.

<table>
<thead>
<tr>
<th>Highest</th>
<th>High</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Concentrate</td>
<td>Dark Green Vegetables</td>
<td>Winter Squash</td>
<td>Meat</td>
<td>Rice</td>
</tr>
<tr>
<td>Liver</td>
<td>Carrots</td>
<td>Eggs</td>
<td>Fish</td>
<td>Milk*</td>
</tr>
<tr>
<td></td>
<td>Mangoes</td>
<td>Papaya</td>
<td></td>
<td>Potatoes</td>
</tr>
</tbody>
</table>

* In some areas milk is fortified with Vitamin A.

CALCIUM:

Calcium is needed for strong bones and teeth. Low levels of calcium in the diet can lead to brittle, poorly formed bones and easily decayed teeth. Calcium is very important in the diets of older women, who often suffer from osteoporosis, or brittle bones. Osteoporosis can determine whether a slip and fall causes a few bruises or crippling broken bones and long periods of immobility.

Several foods are grouped below as sources of calcium.

<table>
<thead>
<tr>
<th>Highest</th>
<th>High</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Concentrate</td>
<td>Dark Green Vegetables</td>
<td>Tortillas*</td>
<td>Rice</td>
</tr>
<tr>
<td>Cheese</td>
<td>Sesame Seeds</td>
<td>Beans</td>
<td>Corn</td>
</tr>
<tr>
<td></td>
<td>Milk**</td>
<td>Meat</td>
<td>Fruit</td>
</tr>
</tbody>
</table>

* In Mexico and some parts of Central America corn tortillas and other corn products make up a very large part of the peoples' diet. Traditionally, the corn is prepared by first soaking it overnight in limewater. This process, called Nixtamalization, adds substantial quantities of calcium to the diet.

** The majority of the adults in the world are, at least somewhat, lactose intolerant. This means they are not able to digest lactose, the sugar in milk. There is more on this subject in the "Discussion Topics" chapter.
IODINE

Iodine and folic acid are two other essential nutrients that are frequently deficient in the diets of low-income people in developing countries. Iodine is needed to help us regulate our metabolism, that is, how fast our engine runs and how quickly we burn up fuel. It is abundant in fish, seafood, and seaweed. Whether plants contain adequate iodine depends very much on how much iodine is in the soil. Many regions have soils that are depleted in iodine. In these regions iodized salt, if available, is good protection against this deficiency.

Plants from the cabbage family, including kale, collards, broccoli, and turnip greens contain goitrogens, or substances that block the absorption of iodine. Cooking deactivates these. Cows that are fed large quantities of forage kale can pass the goitrens on in their milk, and children drinking this milk can become iodine deficient.

FOLIC ACID

Folic acid, sometimes referred to as folacin, helps us to use iron. It is often in short supply in anemic people. Fresh green vegetables and wheat germ are excellent sources of folic acid. Whole grains and leaf concentrate are good sources. Folic acid is sometimes prescribed for pregnant women, as they are especially prone to the deficiency. Some caution should be exercised in using folic acid supplements, however, because high levels of folic acid can mask the symptoms of pernicious anemia, which is an inability to absorb or utilize vitamin B-12 or cyanocobalamin. This is a fairly rare disorder.

VITAMIN E

Vitamin E is an antioxidant that protects the body from lipid peroxidation, an oxygen reaction that turns cholesterol into more toxic forms implicated in hardening of the arteries. It has also been shown to offer protection against some forms of cancer and to improve general functioning of the immune system. The exact mechanisms by which vitamin E works are not yet fully understood, but there is widespread agreement among nutritional scientists that it is far more important to maintaining good health than was previously thought.

Six grams of dried LC provides about 20% of the USRDA (United States Recommended Daily Allowance) of vitamin E. Sunflower seeds, nuts, wheat germ, and vegetable oils, such as soy, corn, and safflower are other excellent sources of vitamin E. This vitamin does not occur in animal products.
SECTION III

AGRICULTURE

A successful leaf concentrate program will usually have three components of roughly equal importance:
- producing the leaf crop
- processing the crop into leaf concentrate
- marketing or distributing the products

This section will address the first of these. In many projects the cost of the leaf crop represents one half of the total cost of producing leaf concentrate. It is usually the biggest single expense, and the most obvious place to look for ways to reduce production costs. Insufficient supply of fresh leaf crop in top condition is a persistent problem at most leaf concentrate projects.

WHO SHOULD GROW THE LEAF CROPS?

Often it has been assumed that local farmers would be producing forage crops that could be used by projects, and the project would be able to purchase leaf crop from a dependable local market. This has been the exception for several reasons. Even where a suitable forage crop, such as alfalfa, is commercially grown, it may not be harvested in such a way as to be available on a daily basis. In northern Mexico we have a project in an area of large irrigated alfalfa fields that yield very well. However, almost all of the crop is cut for hay. This means that 100 hectares may be available for leaf concentrate production today and it will all be mowed for hay tomorrow. In some locations where leaf concentrate could have a major benefit on malnutrition, there is no suitable forage crop currently under commercial cultivation. This is the case in Nicaragua.

In Bareilly, India farmers had several concerns that dampened their enthusiasm for growing leaf concentrate crops. Among these were the perception that the crops needed to be weeded more often than other crops; that cutting a relatively small amount of leaves each morning would ruin a small farmer's chance of securing day labor; and that unfenced animal could eat the leaf crop.

Small leaf concentrate projects will rarely purchase enough crop to entice many farmers to alter their normal growing and harvesting techniques. A project may decide the most economical and dependable way to supply adequate leaf crop is to grow it themselves. Or it may be possible to contract with a few farmers to supply the crop. Both approaches have their pitfalls.

A group that is undertaking a leaf concentrate project will usually have its hands full with processing and distribution of the leaf concentrate. Growing leaf crops brings in a new set of work conditions and problems and may spread the project management too thinly. Agricultural experience and skills are not quickly acquired and several groups have failed miserably at producing their own leaf crops because they were not farmers by trade. Ownership of land can be very expensive and renting or leasing it may not provide much
security. Agricultural equipment can also be an expensive and complicated arena for a small leaf concentrate to enter. If irrigation is being used the cost can be daunting and management of irrigation systems can be complex.

Contracting a few farmers to supply your project with fresh leaf crop can leave you completely dependent on one individual. The farmers may try to take advantage of this dependency by overcharging for leaves, or by wetting the leaves beforehand if they are sold by weight. Contracting more farmers can spread out your dependency, but it also means that you have to deal with several people. You may have to coordinate a schedule of sales among the several farmers. If you are buying 200 kg per day from one farmer, that may represent a very important source of income for him that he will protect by meeting your expectations as a buyer. On the other hand if you spread your purchase of leaf crop among 5 farmers, the sales may not be important enough to any of them to assure that you get priority treatment as a consumer.

There is no easy answer to this dilemma. Any solution will have to take into account the many specific conditions of your project and the agricultural realities in the area. A couple things that may be useful are to select a member of your group or cooperative to take primary responsibility for making sure the leaf crop arrives on time and in good condition. This person could be someone who already has agricultural experience, or you could try to recruit a person with farming skills into your group to widen your base. It may make sense to send a member to some type of agricultural training course. Both regional and foreign agricultural schools and universities often have programs to give students hands on experience by working with charitable organizations. This can be a great source of free or nearly free specialized help, but it best not to have unrealistic expectations of what students will accomplish. If you are contracting a farmer or several farmers it will probably be useful to have them observe the leaf concentrate process and the feeding of malnourished children. This will help the farmers identify with the project and to understand its importance to their community.

**CHOOSING LEAF CROPS**

Not all leaves are suitable for making leaf concentrate. There are an estimated 350,000 species of flowering plants in the world and it is unlikely that as many as 500 of them have been evaluated as possible leaf concentrate source plants. While hundreds of species of plants have been evaluated for making leaf concentrate; in any region there are usually 2 or 3 that are the most productive or the most economical. It is important that more plants be tested. Leaf For Life and a few other groups, notably TRIADES in Hawaii, as well as several more academically oriented institutes, continue evaluating crops for their potential to make leaf concentrate. The following information should help you to understand the process of selecting crops better and to give you a sense of what has already been done.

While we'd like to avoid the dissipated energy from continually reinventing the wheel; it is worth noting that a good many improvements in wheel technology have taken place.
since the original invention was made. We have found on many occasions that our field test results differed from a published report on a crop, sometimes for better and sometimes for worse. If you are planning to do some testing of possible leaf concentrate crops, it is worth remembering a few things that might make your work more useful to other people working in this field. Use scientific, in addition to local names for crops. Local names like Chinese Spinach or quelite may refer to several different plants in different locations. Everyone in southern India may know what Patsam or Makchari is, but it is impossible for a Latin American worker to find out without the scientific name. Use the metric system of measurement. Record as much information as possible. The age of the plants at harvest, the cultivar or variety of a plant if it is known, the method of processing, are all-important if we are trying to compare the performance of different plants. The moisture content of the plant leaves and the leaf concentrate are probably the most important. Field reports of very high yields for LC without identifying the moisture content are meaningless. I've read a detailed analysis of leaf concentrate from Bolivia that was 83% moisture. Others are as low as 55%. There is a difference between the weight of dried LC (which is usually around 10% moisture) and the dry weight of LC (0% moisture). The chart on yields at the end of the agricultural section will give you a good idea what constitutes a good yield. It is calculated from the dry weight of the leaves to the dry weight of the LC. Both should be dried for 12-16 hours at about 100° C, to determine dry weight.

**GENERAL NOTES ABOUT SELECTING CROPS FOR LEAF CONCENTRATE PRODUCTION**

Three great divides separate potential leaf crops quickly into functional blocks:

1. Tropical vs. Temperate and Subtropical plants
2. Perennial vs. annual plants
3. Legumes vs. Non-legume plants
4. Tropical plants normally thrive in hot climates and don't tolerate frost. Temperate plants are adapted to areas with a cold winter and warm summer. Subtropical plants are best suited to the edge between the tropical and temperate zone or to higher elevations within the tropics. Most of the research that has been done on leaf concentrate has been done in temperate zones in Europe and the United States and more information is available on temperate crops as sources of leaf concentrate. Medicago sativa (alfalfa or lucerne) is a temperate, perennial legume that has been studied extensively and is used in commercial leaf concentrate production for animal feed. It is the benchmark crop against which leaf concentrate crops must be compared. In addition to alfalfa, temperate and subtropical leaf concentrate candidates include clovers (especially berseem); members of the cabbage or mustard family, small grains such as wheat and oats, and chenopods, including beet greens, lambsquarters, Swiss chard, orach, and quinoa.

Many of the temperate zone candidates are commonly eaten as vegetables and have been bred for centuries to reduce the levels of toxic or bitter components. Economically, it is difficult to compete with alfalfa which can yield up to 120 tons of green matter per hectare, fixes its own nitrogen from the air, can be cut many times a year, and only needs
to be replanted every 4-8 years. Some mixes of annuals, for example wheat and mustard, may give even greater yields and have milder flavored curd than alfalfa, though they would require more labor and energy inputs as well as nitrogen fertilizer.

One area of interest is by-product leaves of commercial vegetables, such as beets, cauliflower, radish, and sugar beet. A leaf concentrate operation near a packing plant could potentially improve the economics of growing these vegetables by making a high value product from leaves that are currently low value or a disposal problem.

Tropical plants must receive more of our attention for several reasons. As stated above, there are already good LC crops in the temperate zones. Even more basic is the fact that LC is much more needed in the tropics. The humid tropics have a large number of people, the fastest growing populations, the greatest prevalence of malnutrition, and the fewest technical and financial resources with which to meet the food requirements of its people of any region on earth. Compared to the temperate zones, the tropics have a longer growing season but generally more problems with insects, viruses, fungus, nematodes and noxious weeds. Tropical soils tend to be more fragile and less fertile. Soil moisture and nitrogen are lost much more quickly to the air because of the high temperatures. Generally far less systematic breeding has been done with tropical leaf crops and they often exhibit tremendous genetic differences from one variety to another.

If alfalfa is the benchmark crop for the temperate zones, I would suggest, for the time being that Vigna unguiculata (cowpeas) is the tropical plant against which all candidates be compared. Cowpeas are not as strong an LC crop as alfalfa, but they are eaten as a leaf crop in many countries, thrive in hot humid conditions, come up quickly, and produce good yields of mild flavored leaf curd. They are well suited to a variety of intercropping schemes, are capable of fixing large amounts of atmospheric nitrogen, and make a good green manure crop. The humid tropics have much greater diversity of plant life than the rest of the planet, and as a result there are thousands of plants that may have potential as leaf concentrate sources.

Although the great majority of plant species have never actually been processed for leaf concentrate, we can narrow the search very quickly by applying a set of criteria for plants we hope to use to make leaf concentrate, by looking for plants that maximize the positive characteristics given below and minimize the negative ones.

Positive Plant Characteristics in Potential Leaf Concentrate Sources

- known to be edible by humans in the area where it would be used
- palatable to animals
- consistently yields large amount of green forage (30 tons per hectare per year or more)
- produces green forage over most of the year
- moisture content of fresh leaves above 75% and below 90%
- protein content in fresh leaves at least 2.5%
- can fix atmospheric nitrogen (leguminous plants like beans, peas, clovers, alfalfa and many tropical trees have nodules on their roots that can turn the nitrogen in the air into nitrates that can be absorbed by plants)
- can be used as a green manure or be intercropped with local commercial crops
- erect, non-twining growth habit for ease of harvest
- resistance to common tropical virus, insect, fungus and nematode problems
- establishes quickly enough to compete with weeds
- leaves will regrow after harvest for repeated cuttings
- seed or cuttings for propagation readily obtainable
- can withstand drought
- can tolerate low fertility, aluminum, and acidity in soil
- can tolerate salinity and high pH
- has multiple purposes (i.e. edible seeds or roots, green manure, useful for industrial purposes such as medicine, paper or textile manufacture)

**Negative Plant Characteristics in Potential Leaf Concentrate Sources**

- high concentrations of toxins, especially toxic amino acids in plant leaves
- high levels of tannins or phenolic compounds that can bind with proteins and make them difficult to absorb (this can often be determined by leaf juices spontaneously coagulating at room temperature)
- leaf juice forms bitter or unpleasant tasting curd
- leaf juice that doesn't coagulate readily when heated to boiling
- mucilaginous leaf juice that is difficult to separate from fiber. A simple rule of thumb is to rub a few tender leaves from the plant in question between your fingers; the juice released should be thin and watery not thick or sticky.
- acidic leaf juice
- leaf juice that forms a very fine soft curd that is difficult to separate from whey
- leaves that are difficult to harvest (how long will it realistically take to harvest 200 kg of fresh leaves from this plant? This is usually a minimum daily amount for an
economical production site. An experienced Mexican farm worker can cut 200 kg of alfalfa in 15 minutes with a scythe.)

SUGGESTED POTENTIAL LEAF CROPS

As of April 1993 I would recommend one of the following leaf crops to people who would like to begin working with leaf concentrate and who do not want to get involved with any crop testing:

Medicago sativa (alfalfa or lucerne)
Vigna unguiculata (cowpea)
Trifolium alexandrium (berseem clover)
Dolichos lablab (lablab or hyacinth bean)
Clitoria ternatea (butterfly or Kordofan pea)
Brassica oleracea (collards or kale)
Brassica juncea (mustard)
Beta vulgaris var. cicla (Swiss chard, acelgas)
Atriplex hortensis (orach, mountain spinach)
Triticum x aestivum (wheat, trigo)
Manihot esculenta (cassava, manioc)

Below is a more extensive listing of plant species that have been recommended by various workers as sources of leaf concentrate. I've tried to give some of the pros and cons of each along with some other notes and sources of seed. Addresses of listed seed companies are at the end of this section. There is not a lot of information available on some of the crops, and some of these may prove to be unsuitable after further studies are done. We will try to keep this list updated to include information as it comes to us. Please send us any relevant information you might have gathered on any of these crops or on others that you feel should be included in this list. Thanks!
**LEGUMES (ANNUALS)**

**Canavalia ensiformis - Jack Bean**
*Tropical/Subtropical*

**Pros:**
- grew very well in trials at San Juan del Sur, Nicaragua
- both jackbean and swordbean (C. gladiata) leaves are eaten as potherbs in Asia
- easily established
- withstood long dry season well

**Cons:**
- possibility of toxicity; green beans are reportedly toxic
- no information on how well it coagulates or processes

**Notes:**
- closely related to C. gladiata (swordbean) another useful tropical legume used as a green manure but with strong possibility of toxicity problems

**Seeds:**
- ECHO; Banana Tree; J.L. Hudson Seedsman; B &T Associates; Kumar International; Phoenix Seeds; Inland and Foreign Trading Co., Ltd; Setropa Seeds

**Crotalaria juncea - (C. ochroleuca) Sunnhemp, Sun Hemp**

**Pros:**
- top performer for weight and speed of growth in Muniguda trials in India
- processed easily
- yielded over 5% LC and tasted good
- very high dry matter yields reported (8-20 ton/ha)

**Cons:**
- somewhat poisonous to livestock, should not be fed at over 10% of fodder ration
- not well known as a food crop
- can't recommend until toxicity questions are resolved

**Notes:**
- most of the work on sunnhemp has been relative to its value as a bast fiber
- much used as a green manure, less as hay or fodder,
- seeded at 50-240 kg/ha; but heavy seed rate is to insure upright stems for long fibers and may be negative factor to leaf yield
- yields 25% lower without weeding
- 2 cuts can be taken if first is at height of 30-35 cm from ground

**Seeds:**
- ECHO; J.L. Hudson Seedsman; Hurov's Tropical Seeds; Peaceful Valley Farm Supply; Setropa Seeds; Inland and Foreign Trading Co., Ltd

**Cyamopsis tetragonolobus - Guar, or Cluster bean**
*Tropical/Subtropical*

**Pros:**
- did well in trials at Muniguda in India
- reported good yield when closely planted and good tasting curd
- leaves eaten in Africa, young pods, and immature as well as mature seeds also eaten
- seeds contain powerful thickening agent with commercial value
81% moisture in leaves
extremely tolerant of salinity (second only to Atriplex)
uses cowpea EL type inoculant
N fixation similar to cowpeas

**Cons:** green crop yield considerably lower than cowpeas and other tropical legumes
requires high levels of phosphate in soil (200-250 kg/ha) though his increases
yield of following crops

**Notes:** bushy plant to 3 meters tall
needs 400-500 mm annual rainfall, 900 mm optimum
high rainfall and heat best for green crop, but lowers quality and yield of seed
prefers pH 7.5-8.0
seed planted 2.5-3 cm deep at 8-15 kg/ha
didn't break down as quickly as Crotalaria juncea in green manure trial in India;
may need at least two months before following crop is planted
best forage yields at 51 cm between rows

**Seeds:** - ECHO; Banana Tree; J.L. Hudson Seedsman; Peaceful Valley Farm Supply;
B &T Associates; Kumar International; Setropa Seeds

**Dolichos lablab (Lablab purpureus)**- Lablab Bean, Hyacinth, Bonavist,
Jacinto, Gallinita, Poroto de Egipto, Frijol de Adorno, Tonga Bean.

**Tropical/Subtropical**

**Pros:** leaves eaten both fresh and dried
one of top selections from Puerto Rico LC trials of tropical plants
large seeds good for drilling
retains foliage longer than cowpeas
drought tolerant
grew very well in trials in San Juan del Sur, Nicaragua
good nitrogen fixation even without inoculant
recommended by Ram Joshi in India and by Telek in Puerto Rico
fodder yields of 5-10 ton/ha dry matter have been reported
succesfully intercropped with corn
young pods and mature seeds have commercial value in many countries; used as
vegetable, tofu, tempeh, sprouts. also has large starchy edible root. good multi-purpose
crop

**Cons:** slow early growth
yielded poor curd and small quantity in Nicaraguan field test
lablab forage has reportedly affected the flavor of milk from cows
high percentage of vines and stems may make pre-chopping necessary
reportedly very sensitive to flooding

**Notes:** very poor regrowth when cut below 25 cm
benefits greatly from superphosphate application (250 kg/ha) Highworth and Rongai good forage varieties 89 % moisture in leaves; 86 % in stems 400 mm minimum rainfall, 750 - 1000 mm is optimum, over 2500 mm unacceptable with dense growth lower leaves are shed; they are lost for LC but make good mulch can cause bloat in cattle makes good silage with 2 parts sorghum; protein is 8.1% vs. 4.5 % for plain sorghum forage. often takes four days for cattle to accept lablab forage 75% germination of seeds some damage from leaf-eating insects and nematodes reported seeding rates reported at 20-70 kgs/ha seed for dense stand needs water for 10 weeks then very drought resistant sometimes seeded between coffee trees, after 2 months further weeding is unnecessary fresh seeds may contain dangerous levels of hydrocyanic acid, darker colored seeds contain more; need very thorough cooking and change of water

*Seeds:* ECHO; J.L. Hudson Seedsmen; Hurov's Tropical Seeds; B &T Associates; Setropa Seeds; Queensland Agricultural Seeds Pty.,Ltd; Primac Seeds; Phoenix Seeds

**Mucuna deerianga or Mucuna spp - Velvetbean, Terciopelo**

*Tropical/Subtropical*

**Pros:** grew very well in trials at San Juan del Sur, Nicaragua widely promoted throughout Central America by International Clearing House on Cover Crops good nitrogen fixation (up to 200 kg/ha) easily established withstood long dry season well

**Cons:** likelihood of toxicity. Even the Clearing House cautions against using velvetbean in quantities equal to other pulses. Most of the participants in a velvetbean demonstration in Nicaragua experienced nausea and headache. Too little is known about the chemistry of the leaves and the variation in their composition from variety to variety and under different agricultural conditions. It also appears that sensitivity to toxins from velvetbeans varies greatly from person to person. it can be extremely tangled and presumably difficult to harvest as a result

**Notes:** a commercial source of L-Dopa used in treatment of Parkinson's Disease sometimes called M. pruriens seeds usually sowed 15-90 cm apart in rows 90 - 180 cm apart; broadcast doesn't work well c. 35 - 45 kg/ha; or 15 kg/ha when intercropped with corn
2-3 cultivations usually necessary to control weeds until plants start vining
cowpea inoculant can be used
dense plantings don't produce good seed yields because of poor air circulation

Seeds:- ECHO; J.L. Hudson Seedsman; Hurov's Tropical Seeds; B &T Associates; Setropa
Peace Seeds; Glendale Enterprises,Inc.; Inland and Foreign Trading Co., Ltd

**Phaseolus lunatus L - Tropical Lima Bean, Madagascar Bean**

*Pros*: well suited to leached low fertility soils common to humid tropics
  shows great promise in African rainforest, a difficult environment for pulses
  leaves eaten as a minor potherb when young and tender in parts of Latin America and Africa
  green and dried beans have commercial food value
  successful intercrop trials with corn in Columbia

*Cons*: most of the breeding has been for seed yield, bushy growth habit, and adaptability to temperate zone; none of which serves our purpose
  not well tested as LC source
  seeds require longer cooking time than other pulses and may contain dangerous amounts of HCN. White seeds usually safe; dark seeds need to be boiled very thoroughly and have water thrown out

*Notes*: has perennial as well as annual forms
  viny unselected varieties performed better than improved bush type in African trials
  indigenous to South, and Central America and the Caribbean
  seed harvest varies from 3-9 months with 5 months typical

*Seeds*: ECHO; Eden Seeds

**Phaseolus vulgaris - Common Bean, Frijol**

*Pros*: leaves eaten as a vegetable in much of Africa and Asia
  very well known and accepted
  seeds widely available
  seeds and immature pods have strong commercial market

*Cons*: slower starting than cowpeas
  seeds normally selected for seed yield at expense of foliage
  usually do poorly in very wet tropics
  most cultivars can't tolerate standing water even for a few hours

*Notes*: prefer cooler subtropics, 800 -2000 meters, usually cowpeas will do better in humid lowlands
cultivation must be shallow, especially in closely planted rows to avoid root
damage.

usually planted in rows 70 - 80 cm apart, 5-10 cm between seeds, and 5 - 8 cm
deep

in Nicaragua are normally planted in rows 80-90 apart. This is tied to the space
needed to cultivate with oxen. We are testing a system of planting beans in rows 16”
apart with the wheel seeder and cultivating them with the wheel hoe. When they get too
crowded we harvest every other row to make leaf concentrate. This system could
potentially produce far more nutrients per acre with less work. By having an extra row of
beans between the wide rows, weeding would be easier, the soil would be improved and
the land would yield leaf concentrate and fiber for animals as well as beans.

c. 87 % moisture;  3.6% protein in fresh leaves

bean leaf yield usually improves markedly with added phosphorus in the soil
small seeded pole types should produce more foliage than bush types, half runners
are intermediate

many varieties used for centuries as intercrop with corn; 70 % of beans in Latin
America are intercropped

over 14,000 cultivars worldwide with very large variety of characteristics
seeding rate of 100 kg/ha probably good for foliage; as low as 25 kg/ha for beans;
with lower seeding rates for pole types than bush types

bush beans are normally planted 5-8 cm deep; in rows 50 cm apart; with 5-10 cm
between seeds

inoculation of seeds usually not necessary

Vigna aconitifolia - Moth Bean or Mat Bean

Tropical/Subtropical

Pros: relatively well known bean crop
forage 75% moisture;
7.5 - 10 tons/ha dry matter
excellent forage and green manure crop
very drought resistant
adapted to very hot climates

Cons: low creeping growth habit could make this crop difficult to harvest and to clean
not well tested as LC crops
not eaten as potherb

Notes: prefers dry sandy soils
prefers 500 -7500 mm rainfall
sea level to 1300 meters

Seeds: - J.L. Hudson Seedsman;   Hurov's Tropical Seeds;   Seeds of Change
**Vigna unguiculata** - (Vigna sinensis) Cowpeas, Frijol de Vaca

**Pros:**
- Well known to be edible, leaves eaten as vegetable in many African and Asian countries.
- Seeds easily available commercially and very easy to propagate.
- Germinates well.
- Grows very quickly compared to many tropical legumes enabling it to get over weeds with one cultivation.
- Good yield of mild flavored leaf curd.

**Cons:**
- Somewhat prone to virus.
- Sensitive to frost and flooding.
- Annual that won't take repeated cuttings, needs replanting at least every 12 weeks.

**Notes:**
- Moisture content 85-89%; protein much higher at 89% than 85%.
- Huge number of cultivars are commercially available including California blackeye #5, Magnolia, Mississippi, and Vining Purple Hull that have been bred for resistance to fusarium, root knot nematodes, wilt and other viruses.
- Most of the breeding for resistance has been done with bush type heavy seed yielding varieties, whereas the best foliage varieties like Iron and Clay, and Whippoorwill have not been bred much for resistance. Disease has not been a big problem in Nicaragua over 4 years.
- March 1993 report from Nicaragua shows harvests of irrigated cowpea forage at about 550 grams per square meter. Estimated 57 tons/ha green crop per year.
- Dry LC is about 2-2.25% of fresh crop or c. 1.4 tons dry LC per ha per year or enough LC for about 930 children to receive a 6 gram portion M-F all year.
- Research on cowpeas is being done at International Institute of Tropical Agriculture N.Q. Ng Head OYO Road PMB 5320 Ibadan, NIGERIA tel: 400300 400314 whose European contact is: IITA c/o Ms. Maureen Larkin, Carolyn House 26 Dingwall Rd. Croydon CR9 3EE UK fax 44 81 681 8583. They may be willing to provide test packets of cowpea varieties.

**Seeds:**
- Widely available. Iron and Clay, and China Red are the most widely available forage types in the US. Inoculant from Peaceful Valley Farm Supply~ P.O. Box 2209–Grass Valley–CA 95945, USA tel: 916 272 GROW FAX= 916 272 4794 or Liphatech 3101 W. Custer Ave. Milwaukee, WI 53209 USA tel: 414 462 7600 or from many larger seed dealers. Typical price $20 US for 50 lb (c.23 kg) sack.
**LEGUMES (PERENNIAL)**

**Calopogonium mucunoides - Calopo**

*Tropical*

*Pros:* Native to Nicaragua, well suited to humid tropics
  tolerates acid lateritic soils
  yielded c. 60 ton/ha green manure in 6 months
  nearly 250 kg/ha N fixation
  a self-regenerating annual with good seed production
  can also be propagated from stem cuttings

*Cons:* not known as a human food
  forage not palatable to cattle
  shallow rooted so doesn't withstand long drought
  needs at least 850 mm rainfall, prefers 1250 mm

*Notes:* forms complete cover crop 60 cm thick in 5 months
  often intercropped with citrus, rubber and coconuts

*Seeds:* - Empresa de Semillas Forrajeras

**Centrosema decumbes, C. pubescens - Centro**

*Tropical*

*Pros:* very leafy perennial legume
  easy to establish on poor soil

*Cons:* not known as a human food
  not very palatable to cattle

*Notes:* 5-7 tons/ha dry matter reported
  4-8 months to form dense cover 40-50 cm high
  for forage sow 8 kgs/ha in rows 90 cm apart; more if broadcast at onset of rainy season
  stems are not woody for the first 18 months
  Sometimes planted with Calopogonium mucunoides or Pueraria phaseoloides for quicker cover

*Seeds:* - J.L. Hudson Seedsman; Setropa Seeds; Queensland Agricultural Seeds Pty., Ltd; Kenya Seed Co; Inland and Foreign Trading Co., Ltd; Dumon Agro NV
Clitoria ternatea - Butterfly or Kordofan Pea., Campanilla, Zapatilla de la Reina.

**Tropical**

**Pros:** given top rating by Telek in terms of % protein in dry LC (59.3%) and PER or Protein Efficiency Ratio (2.4) in Puerto Rico trials
- moisture content of green crop c 79%
- perennial legume
- green matter yields of 80 - 100 kg/ha + recorded in Campeche, Mexico and in Cuba
- dry matter yields of 13 tons/ha have been recorded in Australia
- tolerant to drought, alkalinity, slope, virus, and weeds
- can use cowpea EL type inoculant
- very palatable to cattle

**Cons:** no experience with making or using Clitoria LC on other than lab scale
- much lower yield without inoculant and lower protein content
- won't tolerate waterlogging
- slow germination 7-15 days. We've had poor germination twice in Nicaragua

**Notes:** prefers full sun
- twiner; stem grows to 5 meters
- grows from sea level to 1800 meters
- rainfall minimum of 400 mm, optimum 1500 mm; does well with irrigation
- flowers cerulean blue, used to tint boiled rice, as litmus substitute, as ornamental
- covers the ground in 4-6 weeks when sown 25 cm apart in rows 1 meter apart, dense enough to smother weeds in 4-6 months
- dry matter yields vary greatly from 1 ton/ha in rainfed sandy soil to 13.5 tons/ha in irrigated clay.
- grown with Sudan, elephant grass, sorghum and sunnhemp
- sown 1-3 kg/ha on well prepared seedbed
- nitrogen application depresses growth
- virus problems under wet conditions at Turrialba, Costa Rica
- some grasshopper and nematode problems in Africa
- young pods eaten as green beans

**Seeds:** - ECHO; Banana Tree; J.L. Hudson Seedsman; Chitern Seeds; Inland and Foreign Trading Co., Ltd

Desmodium intortum; D. discolor; D. nicaraguense - Greenleaf

**Pros:** perennial legumes can go 6 years if phosphorus supplied, often 3 without
- can utilize cowpea inoculant
- D. nicaraguense used as forage in Central America, called horse-fattener because of palatability and feed value
- up to 7 cutting per year in Costa Rica.
- grows up to 6 meters but usually cropped back by livestock
can withstand heavy competition from grasses

**Cons:**
- not known as human food
- genus contains several obscure toxins
- forage reportedly high in tannins, though lower tannin Australian cultivar
- "Greenleaf" is available
  - leaves of D. intortum stick to cloth making harvest difficult

**Notes:**
- native to South America usually above 500 meters
- several closely related and frequently confused species
- propagated by seed (c. 6 kg/ha) or cuttings 15-30 cm long
- usually grown with a grass
- frequent weed in coffee plantations
- cuttings below 8 cm can destroy plants
- annual dry matter yield (c. 8 tons/ha) best with 12 week harvest intervals

**Seeds:** Setropa Seeds; Queensland Agricultural Seeds Pty., Ltd; Kenya Seed Co.

**Glycine wightii (Glycine javanica) - Perennial soybean**

**Tropical**

**Pros:**
- perennial legume
- eaten as potherb in Malawi
- palatable forage
- tolerates acid soil and shade
- yields c. 7-10 tons/ha dry matter

**Cons:**
- little done on crop as LC source

**Notes:**
- c. 89% moisture
  - attempts to cross with soybean have been unsuccessful
  - can climb over trees and shrubs like kudzu
  - propagated from seed; c 7-9 kgs/ha
  - prefers 750 - 1000 mm rain
  - when mixed with grasses, including sorghums and millets yielded 10 -13 tons/ha green matter every 40 days (over 100 tons/ha green matter per year)

**Seeds:** Setropa Seeds

**Macroptilium atropurpurium (Phaseolus atropurpureus) - Siratro**

**Pros:**
- native to Mexico and Central America
  - long-lived perennial
  - deep taproots provide drought resistance
  - tolerates alkaline soil and high aluminum levels
  - can use cowpea inoculant

**Cons:**
- disease prone in very humid regions
Notes: prefers subtropical conditions to 2000 m or drier tropics (700 cm per year)
  prefers deep sandy soil
  can't tolerate waterlogging
  more tolerant of low fertility then Desmodium intortum or Glycine wightii, less
  than Stylosanthes humilis
  won't tolerate high manganese in soil as well as other legumes
  plant at beginning of rainy season
  typical seeding rate c. 3-5 kgs/ha
  benefits greatly from phosphate fertilizer as a rule
  yield increases as cutting interval is extended from 4 to 16 weeks
  up to 11 tons/ha dry matter with 4 cuts; average 5-7 tons dry matter with 2 cuts
  per season
  70-75% moisture

Seeds:--Setropa Seeds;  Queensland Agricultural Seeds Pty.,Ltd;  Kenya Seed Co;  T.S.L. Ltd

Macroptilium lathyroides - Phasey bean, Wild pea bean
  Tropical/Subtropical

Pros: selected by Telek as one of most promising tropical LC plants in Puerto Rico
  high protein
  good extraction
  very palatable to cattle
  rapid regrowth forms dense stand
  could be machine harvested
  good nodulation
  tolerant of waterlogging
  5-12 tons/ha dry matter reported; claim made of 60 tons/ha dry matter potential
  with irrigation

Cons: not known as a human food
  seeds difficult to gather due to shattering
  sensitive to viruses
  sensitive to frost
  seed not readily available commercially

Notes: annual or short lived perennial
  typical seeding rate 1-3 kg/ ha
  protein highest at 79% moisture at 4 months; at 6 months 70% moisture and only
  2/3 the protein per kg dry matter

Seeds: Zentralinstitut fur Genetik und Kulturpflanzen-forshung~Correnstrasse 3~4325
  Gatersleben~GERMANY (non-commercial source; small samples to institutions)
**Medicago sativa - Alfalfa (including tropical varieties)**

*Temperate/Subtropical*

**Pros:**
- best tested of all LC plants
- only plant used to make LC commercially
- deep rooted perennial legume
- yields up to 100 tons green crop/ha with irrigation
- withstands repeated cutting (8 to 15 cuts per year in Mexico)
- dense and erect growth ideal for harvest with scythe or sicklebar cutter
- 80 - 83 % moisture, 5 - 6 % protein

**Cons:**
- strong flavored curd due to saponins; stronger if not well pressed
- attacked by virus and other diseases in hot humid climates

**Notes:**
- tropical varieties have been developed at the University of Florida and in Brazil. these do better in heat but still have problems compared to tropical natives
- In Aurangabad, India alfalfa yielded 150 t/ha fresh crop; 25 t/ha DM; (16.7%) 6t/ha CP; 3.2 (2.13% of green matter ; 12.8% of DM) t/ha extracted protein, with 14-16 harvests per year. Yields were increased by frequent irrigation, NPK, manure and micronutrients, simazine, and closer rows (30 cm rather than 46 cm) and frequent harvest; 8 rather than 5 in 180 days
- alfalfa is a potential source of a variety of medicinal and industrial compounds.
- Research has begun at the University of Wisconsin to commercially extract compounds from genetically altered alfalfa. This could potentially be integrated into an LC production scheme.
- seeds are very hard and should be scarified or soaked in water before planting.
- Fresh seed does not germinate as well as seed that is 2-3 years old.
- when broadcast seed rate suggested as 12-20 kg/ha; in rows or ridges 55-72 cm apart 10-12 kg/ha seed used. Ridges or rows facilitates weeding
- usually responds to 250 kg/ha superphosphate per year or 500 kg/ha every other year; also often responds to potassium and sometime s boron
- best harvested at beginning of flowering
- optimum rainfall usually 500-600 mm, where there is over 1000 mm it sometimes grows only as an annual
- in Michoacan, Mexico (c.2000 meters) yields c. 80 tons/ha green matter per year with irrigation; which should yield 1.6 tons dry LC ; enough for 1060 children at 6 grams daily
- good alfalfa sells for $40-70 US per ton in the field in Michoacan, Mexico
- low saponin varieties should be used for LC production

**Seeds:** normally available commercially in alfalfa growing regions. Small packets of tropical varieties from - ECHO; non-hardy, heat resistant variety CUF 101 (grown in California's Central Valley) is available from - Cal/West Seeds; also Ramsey Seed Co; Gunson Seed
Psophocarpus tetragolobus - Winged bean, Goa bean

*Tropical*

**Pros:**
- Leaves eaten as vegetables
- 85% moisture, 5% protein
- One of top performers in Puerto Rico LC trials; PER of 2.2; behind only Clitoria ternatea
- Used as green manure, forage, cover crop, fresh and dried beans, and edible tubers; the ultimate multi-purpose crop
- Tolerates heat and low pH
- Apparently can utilize cowpea inoculant

**Cons:**
- Needs good drainage
- Needs lots of water 1500 mm for good growth; 2500 mm or more for top production
- Little information on leaf yields as it is grown mainly for beans or tubers
- Difficulties in germination in Nicaraguan trials
- Slow starter, needs weeding until established
- Forms tangled mess of vines that could be difficult to harvest and pulp

**Notes:**
- Perennial vine, but often grown as an annual
- Sea level to 2000 meters
- Typically planted 2.5 - 7.5 cm deep c. 10 cm apart for foliage, at beginning of rainy season
- Trellised plants produce twice the seed of unstaked plants
- Picking flowers increases tuber yield

**Seeds:**
- ECHO; Banana Tree; KEO Entities; B & T Associates; Sutton and Sons, (India); Phoenix Seeds; Inland and Foreign Trading Co., Ltd; Tokita Seed Co., Ltd; Setropa Seeds

Pueraria phaseoloides (P. javanica) - Puero or Tropical Kudzu

*Tropical*

**Pros:**
- Perennial tropical legume
- Considered very palatable to livestock
- Does well in high rainfall areas (over 1000 mm per year) if dry periods is not too long
- Good at smothering weeds once established
- Recommended from Venezuelan trials

**Cons:**
- Not used as a green for humans, little information available on its use for humans
- Heavy twining habit with extremely tough fibrous stems (used in ropemaking in some places) could make it hard to harvest and to pulp
- Slow to establish cover

**Notes:**
- 30 - 50 tons green crop/ha possible
**Stylosanthes gracilis (guianensis) - Brazilian lucerne, Stylo, Tropical alfalfa**

_Tropical_

**Pros:** one of highest yielding legumes 15 tons/ha dry matter reported with irrigation and fertilizer; 17 -21 tons/ha dry matter per year considered possible  
can utilize cowpea inoculant  
can accumulate calcium and phosphorus even when levels of these nutrients are low in the soil  
tolerates high aluminum in soil

**Cons:** not known as a human food  
can't tolerate shade  
susceptible to leaf spot infection

**Notes:** typical seeding rate 3 kg/ha broadcast or in rows 45 - 60 cm apart  
benefits from 1 or 2 weedings until established (usually 3-5 months)

**Seeds:** -Setropa Seeds

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**Trifolium alexandrium - Berseem or Egyptian Clover**

_Subtropical_

**Pros:** has been successfully used as LC source in Pakistan, India, and Egypt  
excellent productivity (8-10 tons /ha dry matter with 3 cuts and no irrigation; and 12-18 tons /ha dry matter with 6-8 cuts and irrigation). Generally 2 tons /ha dry matter per cut, yields up to 170 tons green fodder/ha are possible  
more succulent stems than alfalfa, up to 90% moisture; therefore less energy required for grinding

**Cons:** prefers warm temperate climate (12-25 °C), cooler than most of the humid tropic locations.

**Notes:** seed rate 22/50 kgs/ha planted early in wet season  
1.3- 2.5 cm deep  
needs minimum of 250 mm annual rainfall  
won't tolerate frost  
tolerates high pH and virus  
can use commercial white clover inoculant, molasses or other sticking agent helps inoculation  
phosphorus, zinc, copper and boron can become limiting factors  
Feb 93 report from India shows Berseem with 87 -91 % moisture and yielding 32 grams of fresh leaf curd per kg fresh berseem

**Seeds:** -Banana Tree; Hurov's Tropical Seeds; Primac Seeds; Setropa Seeds; Dumon Agro NV~~715
**Erythrina variegata - Tiger's Claw, Indian Coral Tree**

**Erythrina poeppigiana - Poro**

_Tropical/Subtropical_

**Pros:**
- used in living fencepost schemes and intercropped with coffee in Costa Rica produced more foliage than Gliricidium sepium, though less than Leucaena in Indian trials
- lower polyphenol concentration in leaves than Cajanus cajan
- goat milk production increased with E. poeppigiana leaves added to banana and king grass rations
- E. poeppigiana leaves and sugar cane juice successful feed for rabbits and guinea pigs

**Cons:**
- foliage not known as human food
- great genetic variation in quantities of alkaloids present in leaves
- very little known about LC production from these plants

**Notes:**
- Tested extensively at CATIE in Costa Rica
- E. indica leaves in water (5 grams to 15 ml) said to kill nematodes

**Gliricidium sepium - Mother of Cacao**

_Tropical/Subtropical_

**Pros:**
- commonly used in agro-forestry schemes
- living fence
- flowers eaten as potherb or fried

**Cons:**
- leaves not known as a human food
- yielded much less foliage than Erythrina in Indian trials

**Notes:**
- established more quickly than Erythrina in Nicaraguan trials, though Erythrina caught up within 1 year

**Seeds:**
- Hurov's Tropical Seeds; Peace Seeds; J.L. Hudson Seedsman
Sesbania grandiflora & S. sesban - . (Gallito, Sesban)

*Tropical/Subtropical*

**Pros:** extremely fast growing small tree; especially first 3-4 years; often 4 meters 1st year; 8 meters by 3rd
- one of best nitrogen fixers
- widely used as green manure
- seed and inoculant readily available
- nodulation excellent often even without commercial inoculant
- 76% moisture and 8.7% protein
- great potential in reforestation and land reclamation schemes
- excellent potential for firewood in 5 year cycle
- can be planted very densely (c. 3000 stems per ha)
- resprouts vigorously after cutting to stay within height cattle can reach (or people)
- leaves palatable to cattle

**Cons:** difficulties with germination
- foliage quickly stripped by insects in Nicaragua trial
- photoperiod sensitivity in some varieties

**Notes:** In Java yields of 55 ton/ha green matter in 6-7 months, far better than Crotalaria in same experiment
- S. rostrata in Senegal showed potential N fixation of 270 kg/ha *in 45 days*
- biomass and N fixation faster with stem cuttings than seeds
- Ratooning (cutting at or near base and allowing regrowth) gave top yields

**Seeds:** Peaceful Valley Farm Supply; ECHO; Banana Tree; J.L. Hudson Seedsman; B &T Associates; Kumar International

AMARANTHS AND RELATIVES

Celosia argentea - Quailgrass, Soko

*Tropical/Subtropical*

**Pros:** has been used in Africa as a green pot herb
- used to make leaf concentrate, called Sokotein
- did well in trials in Tennessee

**Cons:** curd was unappealing near black color
- requires high levels of nitrogen in soil for top yield

**Notes:** an amaranth with many attributes similar to A. tricolor
- beautiful purple flowers
- edible oil sometimes extracted from seeds on small scale in Africa
Alternathera sissoo (A. sessilis, A. ficoidea?) - Brazilian spinach

**Pros:**
- one of top three candidates in TRIADES LC trials in Hawaii
- used as cooked vegetable
- spreads to smother weeds
- non-twinning

**Cons:**
- propagated from cuttings
- low growing, creeping plant may be difficult to harvest in economically viable quantities (200 - 500 kgs per day) rapidly and without a lot of soil getting into the leaf grinder

**Notes:**
- flowers sometimes eaten
- member of amaranth family
- not well known

Amaranthus tricolor - Bledo forajero

**Pros:**
- comes up quickly, can often be harvested in 3-4 weeks
- large yields possible under intensive cultivation
- c.85% moisture in green crop
- pan-tropic
- seed readily available
- regrowth up to 4 harvests
- protein quality excellent for leaf crop
- tolerates high aluminum content in soil

**Cons:**
- often worked with in LC projects but usually yields poorly
- some tests have given very fine curd that is difficult to separate
- badly attacked by damping off in Rivas, Nicaragua
- very dependent on nitrogen fertilizer for good yields
- doesn't grow well during long periods of cloudy or rainy weather or in partial shade
- prone to bolting (premature setting of seed)

**Notes:**
- numerous amaranth species, including A.cruentus, A. hypochondriacus, A. caudatus are grown for grain-like seeds. Often green shoots and thinnings from these crops are eaten casually as greens.
- some wild amaranths, notably A. retroflexus, A. spinosis, and A. hybridus are often serious weeds. They are eaten as greens sometimes as well, but are not useful sources of leaf concentrate.
- leaves are high in oxalic acid, but most of the free oxalic acid will wash out with "whey" and the crystalline oxalic acid normally passes through the body without bonding with calcium. Free oxalic acid can bond with calcium, which makes the calcium less
available to the human body and can lead to calcium oxalate kidney stones in some people.

leaves high in nitrates, especially in dry weather or when grown with high levels of nitrogen fertilizer. Almost all of the nitrates will also wash out with the "whey" sometimes transplanted at 2-3 weeks when 2-4 leaves are on plant slugs and snails often damage young plants vegetable amaranths have more trouble with insects as a rule than grain amaranths c. 87 % moisture; 3.5 % protein

*Seeds*: - J.L. Hudson Seedsman; Hurov's Tropical Seeds; Peace Seeds; Redwood City Seed Co; Burpee & Co; B &T Associates

**BRASSICAS**

**Brassica carinata** - Ethiopian collards, Texsel greens

*Temperate/Subtropical*

*Pros*: Excellent flavored greens and curd very fast growing one of the most heat tolerant brassicas most salt tolerant brassica most waterlogging tolerant brassica

*Cons*: somewhat prone to bolting heavy nitrogen user least drought resistant of leafy brassicas in Indian trials

*Notes*: breeding program at Texas A & M was promoting this crop as Tamu TexSel

*Seeds*: Texas Foundation Seed Service; ECHO; J.L. Hudson Seedsman; B &T Associates

**Brassica juncea** (B. alba, B. nigra) - Mustard, Mostaza.

*Temperate*

*Pros*: erect fast growing plants did well with wheat in early Rothamstead trials grew very well in San Ignacio, Nicaragua despite hot humid climate

*Cons*: When large amounts were ground quickly in Nicaragua, workers experienced burning sensation on eyes and skin 90-92 % moisture and 2.4-3 % protein is marginal in terms of dry matter for economic production

*Notes*: Grown in India for LC with seeding rate of 30 kg/ha

*Seeds*: Banana Tree; J.L. Hudson Seedsman; Burpee & Co; B &T Associates
Brassica oleracea var. acephala - Collards, Kale, Col Foragera

Temperate

Pros: 83% moisture, 4-6% protein
well recognized as edible leaf crop
tree, thousand headed, and walking stick kale varieties produce huge leaves on tall strong plants

Cons: very slow regrowth
sometimes a strong cooked cabbage smell to curd
need cool nights

Notes: goitregens that limit usefulness of brassicas as forage crops are destroyed by heat in LC process; however, they may remain in the fiber in significant quantity to affect milk. They are passed from forage to milk and can cause iodine deficiency in children who drink this milk.

Seeds: Burpee & Co.; Redwood City Seed Co; Chitern Seeds; B & T Associates; Eden Seeds --numerous varieties; seed widely available

CHENOPODS

Atriplex hortensis - Orach, Mountain Spinach

Temperate

Pros: did very well in Rolf Carlsson's trials in Sweden
salt tolerant
eaten as green

Cons: heavy nitrogen feeder
prefers cooler climate

Notes: in chenopodium family; some members of genus, especially A. nummalaria, are among most salt tolerant plants known. It exudes salt onto leaf surface. Palatable and high in protein but salt content makes livestock thirsty in low water areas. It is possible that LC process would offer a reasonable way to wash out salt in whey and greatly improve value of this crop in saline areas. A. HALIMUS will produce palatable forage when irrigated with saline solution of 30 g/liter of sodium chloride.

Seeds: J.L. Hudson Seedsman; Abundant Life Seed Foundation; Peace Seeds; B & T Associates

Beta vulgaris - Common beetroot, Remolacha

Temperate

Pros: by-product leaves of popular root vegetable
beet greens are eaten as a vegetable in many places

Con: very fine curd is somewhat difficult to separate
leaves may be past peak when root reach maximum weight

Notes: --numerous varieties; seed widely available

**Beta vulgaris var. cicla - Swiss Chard, Acelgas**

*Temperate*

**Pros:** popular leaf vegetable in Mexico and India
some varieties well suited to repeated harvest including Erbette, Perpetual, and Markin Giant

Con: very fine curd is somewhat difficult to separate

Notes: includes leaf beets, which are beets grown for leaves as well as some Japanese cultivars that are mid way between chards and leaf beets.
-numerous varieties; seed widely available in areas where crop is grown

**Chenopodium album - Lambsquarters, Fat Hen**

*Temperate*

**Pros:** did very well in Rolf Carlsson's trials in Sweden
a common weed in disturbed soil
eaten in northern Mexico as Quelite, a spinach substitute
82 % moisture

Con: prefers very rich land

Notes: related plants including C. bonus henricus (good King Henry) and C. quinoa also can be used to make leaf concentrate.
Luis Fuentes in Bolivia reported that quinoa leaves were too dry to extract well, but they may have a higher moisture content grown in a wetter area than the Bolivian Altiplano

Seeds: - J.L. Hudson Seedsman; Abundant Life Seed Foundation; Bountiful Gardens; B &T Associates

**GRAINS**

**Avena sativa - Oats, Avena**

*Temperate*

**Pros:** used in Bareilly project in India

Con:
Notes: similar to wheat
- numerous varieties; seed widely available in areas where crop is grown

**Pennisetum glaucum (P. typhoides, P. americanum) - Pearl millet**

*Tropical/Subtropical*

**Pros:** very fast growing c-4 crop
- good flavor to LC reported in India
- adapted to sandy soils with under 300 mm rainfall
- erect growth habit for easy harvest

**Cons:** tough and fibrous
- lower yield of LC than legumes
- no N fixation, needs heavy N fertilizer for good crop
- foliage not known as a food

Notes: macerator appears to be well suited to tough fibrous crops, especially non-viny ones
- slender leafy Egyptian varieties better than grain type
- 81-86% moisture
- seeding rate c.5 kgs/ha

**Seeds:**
- ECHO; Seeds of Change
- numerous varieties; seed widely available in areas where crop is grown

**Secale cereale - Rye**

*Temperate*

Notes: similar to wheat
- used as a green manure sometimes because its vigorous branching roots open up soil and add organic matter along with the green tops
- perennial ryegrass (Lolium multiflorum) gave good LC yield in New Zealand trials
- numerous varieties; seed widely available in areas where crop is grown

**Triticosecale sp. - Triticale**

*Temperate*

**Pros:** hardy to cold, reportedly grows well in Bolivian altiplano
- erect plant 120-200 cm tall should be easily harvested with scythe
- seeds valuable grain crop

**Cons:** needs nitrogen fertilizer for good yield
- doesn't thrive in humid tropics
Notes: a cross between wheat and rye

Seeds:- Good Seed Co.; Sharp Bros. Seed Co; Chambers Seeds

Triticum x aestivum - Wheat, Trigo  

Temperate

Pros: used successfully in early trials at Rothamsted  
young wheatgrass extracts easily  
erect growth should be easily harvested with scythe or sickle bar cutter  
fall planted wheat could give very early forage harvest in spring in temperate zones

Cons: needs nitrogen fertilizer for good yield  
doesn't thrive in humid tropics

Notes: Thinopyron intermedium (Intermediate wheatgrass) is a related species that may have more potential as LC source. It is being tested at Rodale Research Center as a perennial grain  
-numerous varieties; seed widely available in areas where crop is grown

OTHERS (PERENNIAL TREES & SHRUBS)

Moringa olifera - Horseradish, Marango or Drumstick Tree, Benzolive, Malungay  

Tropical/Subtropical

Pros: Indigenous tree in much of Central America  
leaves eaten cooked  
ECHO reported success making LC from moringa  
good fencepost crop  
a tree crop whose roots can get water and keep foliage green when field crops are brown  
roots used as horeradish substitute  
seeds reportedly yield good cooking oil (though we didn't have much success separating it in Nicaragua)  
seeds reportedly useful for purifying drinking water  
does well with low rainfall

Cons: we had trouble separating mucilaginous juice in Nicaragua, though ECHO reported good results  
trees would be difficult to harvest 200 kg of leaves from compared to field crops

Notes: TRIADES reports African moringa (Moringa stenopetala) has larger and more palatable leaves and is generally more desirable
Sauropus androgynus - Asparagus bush, Katuk. Sweet leaf bush

Pros: one of top three candidates in TRIADES LC trials in Hawaii
leaves can be eaten raw
growing tip is asparagus-like delicacy (it needs shade to be use as asparagus)
easily propagated from seeds or cuttings
adapted to wet tropics
YIELDS UP to 80 TONS GREEN LEAVES /HA reported
recommended as vegetable crop by Franklin Martin in Puerto Rico and by ECHO
leaves available year round

Cons: frequent usage reported to cause bodily pains
speed of leaf harvest on small shrubby tree?
Martin Price of ECHO reported a failure of Indonesian large plantation for shoots
because of high labor requirements
heavy N feeder

Notes: 81 % moisture
8-10 weeks to first harvest
likes about 70% of full sunlight
leaves used to color pastry, make fermented rice, and alcoholic drink
fruits used to makes sweets in Southeast Asia
needs high soil moisture for good shoot production, though shrub will survive
much lower moisture

Seed: - Hurov's Tropical Seeds; The Borneo Collection

Spondias purpurea - Jocote

Tropical/Subtropical

Pros: indigenous scrubby tree crop in Nicaragua
young leaves eaten occasionally raw or cooked, used as tea for colds
possibilities as living fence
make good yield of LC with pleasantly tangy flavor
leaves 5.5% protein; low moisture

Cons: difficult to harvest economical quantities quickly
little known about chemistry of leaves

Notes: S. mombin, S. lutin, S. mangifera, and S. dulcis all related plants whose somewhat tart leaves are eaten either raw or cooked

Seed: - Hurov's Tropical Seeds; B &T Associates; Kumar International
OTHERS (NON-WOODY)

**Azolla pinnata**
*Tropical*

*Pros:* 2nd highest in dry matter (7.8%) of 16 water plants in Calcutta trials
- good quality LC
- aquatic fern that grows in association with nitrogen fixing blue-green algae
- may have potential as LC crop in places to wet for conventional field crops
- may have potential for use in rice paddy intercrop

*Cons:* higher moisture content 92% and lower extractability than legumes

*Notes:* suggested by TRIADES

**Coccinia grandis** - Perennial cucumber, Ivy gourd, Scarlet gourd

*Pros:* one of top three candidates in TRIADES LC trials in Hawaii
- vigorous perennial
- leaves can be eaten raw or cooked
- cucumber like fruits eaten young or pickled
- reportedly used as living fence

*Cons:* wild relatives can become weed pest spread by birds, (to prevent this a sterile cultivar is used which can only be propagated by cuttings)

*Notes:* Little information available on this crop as grown for leaves rather than fruit

*Seeds:* - Hurov's Tropical Seeds; B &T Associates

**Crassocephalum biafrae** - Sierra Leone Bologi

**Crassocephalum crepidoïdes** -Ebolo
*Tropical/Subtropical*

*Pros:* well adapted to growing in light shade. Direct sunlight reported to reduce rate of growth. This could be a valuable attribute for growing in agro-forestry or multi-storied schemes or intercropped with coffee, banana or other large perennials.

*Cons:* little known about this crop as a source of LC
- succulent leaves could be mucilaginous
- propagated by cuttings, rarely by seeds. This makes importation of crop into areas where it doesn't already exist difficult.
- plants very sensitive to dry soil

*Notes:* young leaves and shoots eaten in tropical Africa
more investigation needed before it can be seriously considered
prefers soil with organic content
plants normally established 60-75 cm apart with supports up to 1.5 meters
flowering shoots removed to encourage leaf production
leaf harvest begins in 60-70 days, continues for over one year depending on plant
grow yields c. 15 kg fresh leaf per plant per year

Seeds: - Hurov's Tropical Seeds

Manihot esculenta - Cassava or Yuca
Tropical/Subtropical
Pros: leaves high in protein
good yield of LC
pan-tropic
could be one of the biggest protein producers in the tropics
cassava LC could be mixed with starchy cassava tubers to make nutritious food
Zaire study shows that some defoliation can increase tuber yield
in Nicaragua leaves continue to be green well into dry season
Columbian study indicates acceptable digestibility of cassava LC

Cons: may not be easy to harvest in large quantities
serious questions about digestibility of protein due to binding with phenolics
not recommended by Telek in Puerto Rico

Notes: chick studies need to be done
   heating juice to boiling and pressing curd very well should remove c. 95% of
   hydrocyanic acid
   Hydrocyanic acid content of tubers varies from c 14 mg/kg (sweet cassava) to 400
   mg/kg (bitter cassava). Leaves from plants with bitter tubers have much higher HCN
   than leaves from plants with sweet tubers. Taste is not a reliable indicator of HCN
   activity.
   added nitrogen tends to stimulate leaf production and depress tuber yield
   c. 80 % moisture; 6% protein in fresh leaves (moisture content lower in older
   leaves)

Seeds: - Hurov's Tropical Seeds;    B &T Associates
   -numerous varieties; seed and cuttings widely available in areas where crop is
   grown

Sesimum indicum - Sesame, Ajonjoli.
Tropical/Subtropical
Pros: produced good yield of mild flavored curd in Nicaraguan trials
   leaves eaten raw in salads or as a potherb
Cons: Walt Bray reported trouble with mucilaginous juice in several trials in India and the US.

Notes: much grown for seed; little known about production of leaves

Seeds: - Kusa Reasearch Foundation; Chitern Seeds

**Silphium perfoliatum L** - Temperate

**Pros:**
produced very heavy yield in Italian trials
harvested twice (first week of June and mid August yielded up to 200 tons/ha
green crop
  a weed, should have potentia for breeding

**Cons:**
not well known as a human food source
doesn't have easily available commercial seed

Notes: studied in several European countries

**Urtica dioica - Stinging nettle**

*Temperate*

**Pros:**
young leaves are palatable potherb
very high in protein
used by Michael Cole in England

**Cons:**
hares on leaves irritate skin

Notes: leaf juice has been used as a rennet in preparing cheese
prefers rich moist soil of riverbanks
used to make herbal tea
reportedly has anti-fungal effect on plants

Seeds: - Abundant Life Seed Foundation; J.L. Hudson Seedsman

**SOURCES OF SEEDS**

Many of the seed sources listed here deal mainly with very small packets of seeds, sometimes containing a dozen or fewer seeds. This may be enough to see if a plant will grow well in your area or to make a small sample of leaf concentrate. For economic production of LC you will need to develop much cheaper sources of bulk seed. Sometimes these are available locally through seed companies not listed here. You may be able to propagate your own seed from a small packet or two if the growing conditions for that plant are excellent. There are lots of rules restricting the movement of seeds
between countries. You may need to get a phytosanitary document, declaring the seed to be free of pathogens like viruses from the seed source. Find out about this before ordering seeds, or they may be confiscated. Sources in bold type handle seed for several crops listed.

Abundant Life Seed Foundation ~ PO Box 772 ~ Port Townsend, WA 98368 ~USA
tel: 206 385 7192

**B &T Associates**~Whitnell House~Fiddington~Bridgewater~Somerset TA5 1JE~UNITED KINGDOM  tel: 278 733 209

**Banana Tree**~~715 Northampton St.~Easton~PA 18042~~USA~tel: 215 253-9589

The Borneo Collection~PO El Arish~QLD 4855~AUSTRALIA~tel: 70 685 263 (will ship plants to tropical countries, not US mainland)

Bountiful Gardens~5798 Ridgewood Rd~Willits~CA 95490~USA

Burpee & Co.~300 Park Ave.~Warminster~PA 18974~USA~tel: 1 800 888 1447

Cal/West Seeds ~Po Box 1428~Woodland ~CA 95695~USA

Chambers Seeds~15 Westleigh Rd.~Barton Seagraves~Kettering~Northants NN15 5AJ~UNITED KINGDOM~tel: 0933 681 632

**Chitern Seeds**~Bortree Stile~Ulverston~Cumbria~England LA12 7PB~UNITED KINGDOM~tel: 0229 581 137

Dumon Agro NV~Pathoekeweg 40~8000 Brugge~BELGIUM~tel: 32 050 315161; fax 050 315171 (large quantities only)

**ECHO** ~ 17430 Durrance Road ~ N. Fort Myers, FL 33917 USA tel: 813 543 3246

Eden Seeds~MS 316~Gympie 4570~AUSTRALIA~tel: 071 86 5230

Empresa de Semillas Forrajeres~Casilla 593~Tiquipaya~Cochabamba~BOLIVIA~tel: 41975

The Environmental Collaboration~ PO Box 539~Osseo~MN 55369~USA (5 tree minimum for each species) [seedlings]

Gleckler's Seedsmen~Metamora~OH 43540~USA

Glendale Enterprises,Inc.~Rt 3  Box 77 P~Defuniak Springs~FL 32433~USA~ tel: 904 859 2141
Good Seed Co.-Star Rt. Box 73A-Oroville~WA 98844~USA~tel: 509 485 3605

Gunson Seed~Nature Rd~Zesfontein~7409~Petit 1512~REPUBLIC OF SOUTH AFRICA

Harmony Farm Supply~PO Box 451~Graton~CA 95444~USA~tel: 707 823 9125

J.L. Hudson Seedsman~PO Box 1058~Redwood City~CA 94064~USA

Hurov's Tropical Seeds~PO Box 1596~Chula Vista~CA 92012~USA ~tel: 619 464 1017;619 426 0091

Inland and Foreign Trading Co., Ltd.~Block 79A~Indus Rd. # 04-418/420~SINGAPORE 0316~tel: 272 2711 or 278 2193

KEO Entities~ 348 Chelsea Circle~ Land O'Lakes~ FL  34639~ USA tel: 813 996 4644

Kaufman Seed, Inc.  Box 398  Ashdown, AR  71822  USA  tel: 501 898 3328

Kenya Seed Co.~Elgon Downs Farm Research Centre~PO Box 13~Endebess~KENYA~tel: 0325 20941 (42 & 43)

Kumar International~Ajitmal  206121~ Etawah~Uttar Pradesh, INDIA

Kusa Research Foundation~PO Box 761~Ojai~CA 93023~USA

Peace Seeds~2385 SE Thompson St.~Corvallis~OR 97333~USA~tel: 503 752 0421

Peaceful Valley Farm Supply~~P.O. Box 2209~Grass Valley~CA 95945, USA tel:= 916 272 GROW  FAX= 916 272 4794

Phoenix Seeds~PO Box 9~Stanley~Tasmania 7331~AUSTRALIA ~ tel: 00458 1105

Plants of the Southwest~930 Baca St.~Santa Fe~NM 87501~USA~ tel: 505 983 1548

Pocha Seeds Pvt. Ltd.~PO Box 55~Near Sholopur Bazaar~Poona 411 040~INDIA~ tel: 671978

Primac Seeds~PO Box 943~Murwillumbah~NSW 2484~AUSTRALIA~tel: 6166 72 1866

Queensland Agricultural Seeds Pty.,Ltd.~PO Box 1052~Toowoomba, QLD 4350~ AUSTRALIA ~tel: 61 76 30 1000

Redwood City Seed Co.~PO Box 361~Redwood City~CA 94064~USA~ tel: 415 325 7333
AGRICULTURAL MECHANIZATION

For many years the work of Leaf For Life has been very focused on teaching small groups of people, usually women, in tropical countries to make and use leaf concentrate in order to improve the nutrition and health of their families. It is worth remembering, however, that our search for means of producing and distributing leaf concentrate often leads to secondary benefits that may have lasting value for the communities we work with.

In Nicaragua, for example, we are trying to learn how to grow abundant cowpea foliage for leaf concentrate. Like much of the developing world, Nicaragua's agriculture has been shaped by centuries of colonial domination. There is a highly mechanized export sector that uses very expensive equipment to produce sugar, bananas, coffee and cotton. Then there is the subsistence or small farm sector where peasants try to coax enough food for their families with a machete and maybe a hoe. Between the $50,000 tractors and the $4 machete little is available in the way of labor saving agricultural tools. Out of necessity Leaf For Life has become involved in the introduction of appropriate scale agricultural tools.

One of the most promising of these tools is a simple wheel seeder that costs about $75. We introduced these because they enable us to plant cowpeas more accurately and more quickly. They give much more evenly planted rows which has eliminated both overplanting, which wastes valuable seed, and underplanting, which leads to low yields. As the farmer pushes the seeder along it opens a row to the depth we select, drops in seeds at the frequency we chose, and covers the seed with dirt. At the same time it is marking the next row at the distance we chose.
Keeping the rows free from weeds that compete with the cowpeas is another chore that we've had to address. Typically small farmers use either a machete to hack the weeds while bent over in the hot tropical sun or chop the weeds out with a heavy hoe. Both methods are extremely tiring and time consuming. Weeding needs to be done frequently or tough perennial weed grasses take hold and the yield of the crops drops sharply from their competition. We are testing two different types of wheel hoes that cost between $50 and $65. These tools allow the peasant to stand upright and walk quickly down the rows rolling a 20 cm (8") slicing hoe through the weeds. The wheel cultivator is so much easier and faster to use that workers are encouraged to stay ahead of the tough weeds with frequent shallow weeding. With slight modifications we can adjust the wheel seeder to lay out rows that perfectly match the wheel cultivators. Earthway, a US. based company, produces both seeders and wheel hoes; Coles Planet Jr. is a more expensive US. built wheel seeder. Both are available through Peaceful Valley Farm Supply.

Normally beans in Nicaragua are planted in rows 32-36" apart. This is tied to the space needed to cultivate with oxen. We are testing a system of planting beans in rows 16" apart with the wheel seeder and cultivating them with the wheel hoe. When they get too crowded we harvest every other row to make leaf concentrate. This system could produce far more nutrients per acre with less work. By having an extra row of beans between the wide rows, weeding would be easier, the soil would be improved and the land would yield LC and fiber for animals as well as beans.

Preparing small plots of land for planting is another job that plagues the Nicaraguan peasant. Often they contract wealthier farmers to prepare land with tractors. But because they have small parcels to plow they frequently have to wait until after the optimal planting time when the tractors are less busy. The big tractors require a substantial area at the end of the rows in which to turn. This means much of the land in small plots is left
unprepared. We have partially resolved this problem in our small cowpea patches by using gasoline powered roto-tillers or rotary tiller.

We have used a 5 horsepower tiller that costs about $400 and are bringing in an 8 HP and a 14 HP tiller that costs about $1000 and $2500. These are more expensive tools, but still cost far less than the full size tractors. The largest of these is a BCS Italian made walking tractor. It is an amazingly versatile agricultural tool that is becoming quite popular in parts of Latin America. It can prepare small parcels of land quickly for seeds and cultivate weeds. In addition a sickle-bar mower can be attached that enables one to quickly harvest forage crops at an even height. Attachments allow this tool to be used to chop or grind crops for animal feed, pump water, and even haul up to a quarter ton on a cart it can pull behind.

SOME GENERAL SUGGESTIONS FOR GROWING LEAF CONCENTRATE CROPS

Information
- In most areas the farmers and gardeners who successfully grow traditional leaf crops are the best source of information on growing them.

- Try to make connections in the forage or horticulture departments of the nearest college level agricultural school. They can be very helpful in identifying local pests, suggesting varieties that have done well in the area, etc. Use the library.

- Try to find out the scientific name for any serious weed, insect pest, nematode or disease, also scientific names for any local leaf crops that are of interest. This will enable distant workers to help find solutions or to provide useful information. Increasingly, we will be able to use high-speed computer searches to find information quickly.

Water
- The most common limiting factor in leaf crop production is an inadequate or uneven supply of water to the plants. Lush leaf crops require a lot of water. Don't begin a leaf concentrate operation unless you can supply your leaf crops enough water for good growth. Most leaf crops thrive with 2 - 4 cm of water per week throughout their growing season. Once established, plants prefer a thorough soaking every week to ten days over a light sprinkle more frequently. Some plants, like cowpeas, are very sensitive to flooding, so overwatering can be as harmful as underwatering.

- It may be more economical to produce more leaf concentrate than needed during the rainy season and preserve it for the dry season, than to try to irrigate crops through the dry season to maintain year round production. This can be a critical economic decision for a leaf concentrate project. It needs to be carefully thought out. Our experience with irrigation systems in developing countries has not been very positive. Often the capacity of the pumps or of the well or storage tanks is overestimated. Ditches may be clogged
with waterweeds that need to be cleaned out, or they may leak more water than reaches
the plants. An irrigation failure during the dry season can mean a complete crop loss.
Irrigation systems that are not carefully designed to provide adequate drainage of the
added water can lead to salinization of the soil and a serious loss of soil structure. This is
a very serious problem affecting irrigated farming.

- Always it costs more in effort or money or both to grow crops with irrigation than with
rainfall. Usually you can produce much more crop if you can control the amount of water
reaching the plants. Also plants frequently will perform better in dry season with
irrigation than during a rainy season because of greater sunshine and fewer problems with
molds, fungi, and viruses. Try to calculate the additional costs of the irrigation against its
value, and against the additional costs of preserving leaf concentrate and leaving your
workshop and workers idle through the dry season.

- Many plants respond well to irrigation directly after leaf harvests.

### Soil

- Non-leguminous leaf crops are heavy nitrogen feeders. They will yield better with an
application of manure, urea, ammonium sulfate, or other nitrogen fertilizer. Some
leguminous crops will respond well to light feedings of nitrogen, but others like Clitoria
may experience reduced forage yield.

- The value of the nitrogen added to the soil from leguminous leaf concentrate crops
should be considered. We estimate that in Nicaragua $25-35 US per hectare can be saved
by growing cowpeas for leaf concentrate and incorporating the fiber, then switching to
corn production the following year.

- Leguminous leaf crops are usually heavy phosphorus feeders and will respond well to
added phosphorus. This element is frequently deficient in tropical soil and often is the
first factor limiting yields. PHOSPHORUS can improve yield of protein and biomass
from legumes significantly even at 25-30 kg per hectare.

- Have your soil analyzed if that service is available at low cost and follow the fertilizer
and lime recommendations if possible.

- If the soil structure or fertility is poor the residual fiber and whey can be incorporated
into the soil to improve it. Low organic matter in the soil can lead to many problems
including waterlogging, poor utilization of phosphorus, and poor aeration of crop roots.
Manure and crop residues help maintain organic matter in the soil. It is important that
carbon rich residues, such as straw, sawdust, or sugar cane bagasse be mixed with
nitrogen rich sources like manure and leguminous crop residues. The addition of large
quantities of carbon rich material can devastate crops until the soil microorganisms regain
a soil balance. Building up soil organic matter is a long-term undertaking, and it is
impossible to do it adequately in one year or less.
**Planting**
- Seeds should be planted closer together than they are normally. For crops like cowpeas, or lablab that are normally grown for their seeds, it pays to plant at twice the normally density for maximum forage yield. Denser planting is not normally warranted for perennial legumes like alfalfa and pueraria.
- Plant seeds carefully. Planting too deeply is the most common cause of poor germination. If the seeds are carefully spaced in the rows and the rows are straight, the work of weeding will be much easier, and you won't need to thin the plants. When seeds are planted very quickly there is a tendency to have blank stretches and clumps of plants that are too close to each other. Both of these reduce yield.
- Inoculate legume seeds with commercial inoculant if available or with soil from a successful field of the same legume, unless the same crop has been grown on this land within the past three years. For some crops like Clitoria, inoculated plants will produce 25% more foliage, as well as fixing far more nitrogen from the air.
- Leaf crops can often be grown between two rows of another crop, then cut when their leaves begin touching the other crop. This can reduce weed problems and increases the productivity of the land.

**Weeds**
- It is especially important to control weed growth when leaf crop is young and just after leaf harvest. Keeping weeds down until the leaf crop is well established is especially important with perennial legumes, that tend to be a bit slower than annuals getting started. While a few weeds will usually have little effect on LC yield or quality, heavy weeds will compete strongly with your leaf crop for water, nutrients, space, and sunlight and the LC yield per hectare can be drastically reduced.
- Annual weeds are usually best controlled by cultivation, and perennial weeds can often be controlled by repeated cultivation as well. In small patches hand hoeing is often effective. A study in India gave the top rating to a long handled push-pull hoe with a 15-20 cm (6-8") serrated blade set at 70° to the handle. This was considered four times faster than pulling the weeds by hand.
- By far the worst weed problem we've encountered in Nicaragua has been Cyperuses, grasslike perennials in the nutsedge family. They are extremely difficult to get rid of because of their extensive underground roots system. The two essentials to controlling nutsedges by attrition are to cultivate it before they have 5-6 leaves, at which point they begin producing tubers; and to keep them shaded by other plants as completely as possible. They don't compete well in the shade and density of the Cyperus tubers and rhizomes can be gradually reduced until it is not a serious problem. Cyperus tubers can survive up to 4 years in dry soils.
- When the ground is not too wet, a high wheel hand cultivator fitted with a slicing hoe can be pushed quickly through the rows cutting of the Cyperus just below the ground. Where this had been done once every two weeks, the Cyperus was already large enough
to be difficult to cut through and already forming new tubers. Running the wheel hoe through rows just wide enough for it to pass once a week should help keep the Cyperus from being able to photosynthesize and thus from being able to build up the reserves of carbohydrates in its root system that make it so hard to eradicate. Perennial weed grass, like Imperata, can be treated in much the same way as Cyperus.

- There are also wheel hoes and other simple cultivators that are set up to be drawn by animals. In general, draft animals supply more power than humans and greater flexibility than tractors. An ox typically delivers from 0.5 -0.75 horsepower, while a human worker rarely has a sustained output of over 0.1 horsepower.

- We do not usually recommend the use of herbicides to control weeds. They can be an expensive, usually imported habit. Poisoning of farm workers, contamination of ground water, and accidentally killing desirable plants with herbicide is common, especially where workers cannot read warning labels. Where severe infestation of perennial grasses or sedges prevents adequate growth of leaf crops, it may be necessary to use herbicides to gain control initially. If herbicides are needed continually to maintain normal leaf crop yields, you should consider changing the leaf crop to one that can compete better with the weeds, or changing the cultivation schedule to one of frequent shallow weedings until the grasses are weakened.

- Glyphosate (Round-Up) herbicide is probably the easiest and least expensive means of achieving control over perennial nutsedges and grasses. We used glyphosate to control the Cyperus for about 3 months before reinestation. The timing of the application of this herbicide is critical to its success. It should be applied when the Cyperus is about 20 cm high and growing rapidly. Workers at CATIE in Costa Rica suggested an application rate of 2 liters per hectare, with 700 ml mixed with 25 liters of water and delivered through very fine (80001 -80005) low volume nozzles. Glyphosate is a fairly safe chemical in terms of acute toxicity to mammals with an LD 50 of 4320 mg/kg (this is the dosage that kills 50% of laboratory mice), compared with 2,4 -D, for example, which has an LD 50 of 375 mg/kg. Glyphosate is a skin and eye irritant and care should be taken in mixing and handling it.

- Some crops can be used to smother weeds effectively. Closely planted sweet potato vines have been used for this purpose. Velvet beans, kudzu, and desmodium are examples of leguminous crops sometimes planted to smother weeds. These have the advantage of fixing nitrogen and can leave the soil enriched as well as relatively weed free. This technique takes far more time than spraying herbicide.

- Another technique for deterring persistent weeds is called "solarizing". It is useful only for relatively small patches. The soil is tilled or plowed then wetted, then covered with a thin (2 mil) clear or black plastic sheet for 2 to 3 weeks. Clear plastic has been recommended more frequently, but recent tests indicate black plastic may be slightly more effective. Ultraviolet resistant polyethylene will hold up much longer under the tropical sun, but is more expensive and more difficult to find in most countries. In tropical climates the temperature will rise quickly and most grasses will be effectively killed. Many of the weed seeds under the plastic will also be killed. Nematodes and
Pythium (the organisms that cause damping off) will also be killed. Perennial weeds with tubers, rhizomes, or stolons below 10 cm (4”), such as Cyperus will usually recover from solarizing, though they will be weakened.

- Geese have been used to control weeds successfully in some locations. They are especially fond of young grasses and cyperus. About 10 geese per hectare is usually recommended. They have to be enclosed and provided with water and a small amount of additional food. If there is not

**Temperature required to destroy pests**

<table>
<thead>
<tr>
<th>PESTS</th>
<th>TEMPERATURE REQUIRED FOR 30 MINUTES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(° F)</td>
</tr>
<tr>
<td>Nematodes</td>
<td>123</td>
</tr>
<tr>
<td>Damping Off (Pythium)</td>
<td>130</td>
</tr>
<tr>
<td>Most Pathogenic Bacteria and Fungi</td>
<td>150</td>
</tr>
<tr>
<td>Most Soil Insects and Some Viruses</td>
<td>162</td>
</tr>
<tr>
<td>Most Weed Seeds</td>
<td>180</td>
</tr>
<tr>
<td>Resistant Weed Seeds and Viruses</td>
<td>212</td>
</tr>
</tbody>
</table>

**Pests**

- Avoid insecticides if possible. If not use low toxicity ones like neem, rotenone, BT (Bacillus thurengensis) sabadilla or pyrethroids. Wait at least 15 days to process leaves after spraying and wash the leaves especially well. Try safe insect repellents, such as garlic, onion, chilies, or tobacco soaked for two days in water. Then spray this water on the plants, after straining it. If slight insect damage affects appearance of leaves, as they will soon be ground to a pulp anyway.

- Neem (Azadirachta indica) is a tree from India that has been spread throughout most of the tropics. The seeds from the Neem tree can be ground in water to make an insecticide that is safe for mammals, doesn't persist in the environment, and can be easily produced locally, avoiding the cost and dependency on imported insecticides. It is effective in controlling grasshoppers, beetles, aphids, and caterpillars. Neem extract acts both as an insecticide and as a repellent. It doesn't kill instantly, as some synthetic insecticides do nor does it have as long lasting an effect. So it must be used as early as possible after an insect infestation is suspected and it may need to be applied more than once to maintain
control. Neem leaves also have some insecticidal properties, though not as strong as the seeds. They are sometimes packed with beans or other seeds to repel storage insects. The wood from neem is very resistant to termite damage.

- If possible avoid walking through leguminous crops when they are wet from rain or dew. This is one of the main ways that viruses are transmitted. This is not always possible because it is advantageous to harvest leaf crop early in the morning when dew may still be on the leaves.

- Domestic animals belonging to neighbors could be the biggest pests of all. Cows, horses and pigs can damage a leaf crop quickly. Chickens can scratch up new seeds. Fencing in your crop can be a major additional expense if you are working in an area where livestock is roaming freely. Unscrupulous farmers may encourage their livestock to feed on your leaf crops to reduce their feed bill. This is normally a serious matter in agricultural societies, and the offending farmer will often be held liable for your losses.

**Harvest**

- Try to have fresh leaves year round by either adjusting a harvest schedule or by timing the planting of more than one crop. This requires considerable forethought and experience.

- Harvest the plant high enough to allow for rapid regrowth. For example, cowpeas cut at 20 cm above the ground will regrow quickly but those cut at 5 cm will regrow slowly if at all.

**INTERCROPPING**

Intercropping is the growing of two crops in the same field at the same time. It is one of the oldest agricultural practices known. An intercrop normally produces greater total yield than the two crops grown separately. So two hectares of corn and cowpeas intercropped will usually produce about 30% more than one hectare of corn and one hectare of cowpeas. Some plant combinations make more productive intercrops than others. The intercropping of nitrogen fixing leguminous crop with a grain or other heavy nitrogen feeder like bananas is a common practice. Plants that are tolerant to shading are often well suited to intercropping with tree crops or tall plants like maize. Among tropical forage legumes, Desmodium intortum
stands out for high productivity in moderate shade, followed by Pueraria phaseoloides, and Centrosema pubescens.

These are very important in developing countries where yields are often limited because farmers can't afford to buy nitrogen fertilizer, and grain crops often deplete agricultural soils. Farmers are usually primarily concerned with the main crop yield. If that holds up and there is soil improvement, lowered fertilizer costs, or additional food products (ie. beans or LC), the farmer is likely to continue intercropping. If there is a significant decline in the main crop intercropping is unlikely to be continued, even if there are other advantages.

Leaf for Life is studying various intercropping systems using cowpeas and other crops that are suitable for leaf concentrate processing. Cowpeas are the ultimate intercrop plant. Over 90% of cowpeas grown in Africa are grown in intercrop systems. In Nicaragua the intercropping of 4 rows of cowpeas between rows of bananas and plantains has shown a lot of promise. Since the weeds need to be cut from between the banana rows anyway, it makes sense to use that space for a nitrogen-fixing crop. The cowpea leaves are processed into leaf concentrate for child nutrition programs and the fiber and whey returned to the banana plants.

**USING LEAF CONCENTRATE BYPRODUCTS**

Leaf concentrate has been discussed at length in this manual, but what about the fiber and the whey that represent over 90% of the weight of the original leaf crop? When any fresh green leaf crop is processed into leaf concentrate three products are produced: The leaf concentrate, the residual fiber, and the residual liquid or "whey". 100 kg of leaf crop at 80% moisture content should produce about:

- 5 - 7 kg leaf concentrate at 60% moisture
- 44 kg fiber at 70% moisture
- 50 kg "whey" at 94% moisture  (it may have an even higher moisture content from the dew or wash water left on the leaf surface before it was pulped).

Another way of viewing this breakdown of leaves is to figure that 100 kg of fresh leaf crop at 80% moisture should produce roughly:

- 2 kg dry of LC
- 2 kg dry weight of "whey"
- 16 kg dry weight of fiber
- 80 kg water

**RUMINANT FEED**

When figured on a dry weight basis, the fiber left over from leaf concentrate processing has approximately the same feeding value to animals as unprocessed fresh leaf crop. Although much of the protein has been removed in the leaf concentrate, the residual fiber still retains adequate protein good cattle feed. Grinding the leaves up well in the process means that the fiber has far more surface area than the original leaf crop and this
enables the cow’s digestive system to extract nutrients more effectively. Because fresh alfalfa and other leaf crops are usually around 20 % dry matter, while the residual fiber is around 30% dry matter; the fiber has about 1 1/2 times the feeding value, per kilogram, as the leaves that it was made from.

100 kg fresh leaf crop = 80 kg water + 20 kg dry matter
50 kg of fiber = 35 kg water + 15 kg dry matter.

In practice the moisture of forage crops varies from about 75-90 %. If we assume a daily ration of 2 kg dry matter for every 100 kg cow weight, this 50 kg of fiber will feed 2 1/2  300 kg cows. The 100 kg of unprocessed leaf crop would feed 3 1/3 cows of the same weight.

The palatability of leaf concentrate residual fiber is generally quite good if it is fed fresh or well dried. It ferments readily if left in a pile, especially in hot tropical weather, and quickly loses palatability. We have found that cows like it better than do goats or rabbits but all will usually eat it unless they have been very well fed recently. It is a good idea to introduce the fiber gradually in the diet of animals and to make sure they get other feed as well to assure a sufficiently varied diet.

**SILAGE**

Besides drying the fiber for later use it can be preserved by storing it in a silo. This as a technique commonly used in many areas for preserving green cattle feed through limiting the amount of air that comes in contact with the green crop. The action of the anaerobic (living without air) bacteria alters the acidity of the green feed and makes it more stable. Work is being done in India with combining leaf concentrate fiber with bagasse (residue from sugar cane milling) and straw that has been partially broken down with ammonia from urea. This could become a very inexpensive cattle feed and an excellent way to utilize sugar cane waste that is discarded in many tropical locations.

Another technique showing even greater promise is described below:

1. Mix together about 215 liters of leaf concentrate whey, 100 kg of sugar cane bagasse (c. 10 -15% moisture), and 3 kg urea.

2. Pack very tightly into plastic drums or heavy walled plastic bags. This mixture must be well tamped down and well sealed to exclude as much air as possible.

3. Mix together 300 kg fresh leaf concentrate fiber (c.70 % moisture) and 3 kg urea.
4. Pack very tightly into plastic drums or heavy walled plastic bags. This mixture must be well tamped down and well sealed to exclude as much air as possible.
5. Leave both for two to three weeks to enable the anaerobic bacteria to break down the tough fibers.

6. Mix the two silages together and add a small amount of crude molasses and crushed limestone if they are available.

7. This mixed silage is now ready to feed. It will have about the same feed value per kg as fresh alfalfa, and it is an excellent way to make use of the nutrients in the leaf concentrate whey and fiber, so that no part of the leaf crop is lost.

**SOIL IMPROVEMENT**

In locations where the structure or fertility of the soil is low, the residual fiber can be worked back into the soil with a hoe, roto-tiller or plow to improve it. Research in India shows wheat yields were greatly increased when they were planted 30-40 days after a green manure crop of Sesbania sesban or Crotalaria juncea was tilled in. They also found that they could remove some of the nitrogen in the green manure crop as LC and still improve the wheat yields. The wheat yield per kilogram of nitrogen supplied was greater with the LC fiber than with the whole green manure plants tilled in. Because the nitrogen, which is recovered in the LC, is in a form that tropical soil bacteria quickly attack, most of this nitrogen may be lost to the air before plant roots can use it.

Incorporating leaf concentrate fiber can supply nitrogen and improve the structure of the soil by adding organic matter. Leaving green manure crop residues on top of the soil has nearly the same impact on nitrogen availability as tilling the crop in, and it requires less time and energy and will protect the soil against erosion better than the tilled in residues. Well-structured soils rich in organic matter absorb and retain water far more efficiently than soils maintained only with soluble synthetic fertilizers. This means less flooding and less drought damage. It also makes for more efficient use of rains and reduces the risk of salinization from poor drainage in irrigated farmland.

Green manured soils also make better use of phosphorus in the soil by encouraging mycorrhizal fungus. The mycorrhizae aid plant roots in absorbing phosphorus that is often present in tropical soils in forms that are difficult to utilize. Studies at ICRISAT in India showed that chickpeas release mallic acid from their roots that lower soil pH in the root zone and make phosphorus that is bound with calcium more available to plants. Pigeonpeas, on the other hand release picidic acid, which has a similar effect of freeing phosphorus bound with iron. It is quite likely that other legumes have similar beneficial impacts on phosphorus availability.

Preliminary studies have shown that cowpea forage added to soil lowers the acidity and reduces aluminum toxicity more effectively than lime. * Many tropical soils are very acidic and aluminum toxicity is increasingly a limiting factor in crop yields. Spreading crushed lime on fields can be very expensive, especially where transportation is a major problem.
MUSHROOMS

Work underway in India has shown the potential of using leaf concentrate residual fiber as a base for mushroom production. A mixture of one half straw and one half residual fiber was used as a substrate for raising Pleurotus ostreatus (Oyster mushroom). The yield using this mixture was roughly twice what using straw alone produces. Oyster mushrooms are a high priced delicacy in many markets. There are several closely related species of edible Pleurotus mushrooms. All of them are efficient are breaking down the tough lignin fiber in straw.

Pleurotus will convert 100 kg of straw into approximately 10 kg of mushroom; 70 kg of water and carbon dioxide; and 20 kg of spent compost. The spent compost is useful as a cattle feed component, because about 80% of the tough fiber in the straw has been broken down into substances that are more easily digestible by ruminants. A tremendous amount of straw is burned in the field each year in the tropics in order to prepare the fields for the following crop. The burning of straw in the field is one of the world's worst sources of air pollution and the loss of organic matter speeds up the degradation of tropical agricultural soils. The commercial value of straw is often too low to justify the labor involved in collecting and composting it to use to maintain soil fertility. If 10% of the weight of the straw could be converted to high value mushrooms and 20% to cattle feed, there could be a great incentive for farmers not to burn their straw in the fields. The spent compost from Pleurotus culture has also been used as a substitute for chicken manure in commercial plant nurseries in Puerto Rico.

Pleurotus has also been successfully grown on sugar cane bagasse, sawdust and cotton waste. Both the yield of mushrooms and the value of the spent compost are enhanced when the mushrooms are grown on a substrate richer in protein than straw. The leftover fiber from leaf concentrate production has enough nitrogen to enrich at least an equal weight of straw. The 50:50 ratio of straw to leaf concentrate residual fiber should make the Pleurotus culture even more attractive as an alternative to burning fields. This is an area that clearly warrants more practical investigation. (see Technical Guide for Growing Mushrooms in the Tropics, listed in Appendix).
BIO-GAS

Another possible means of using both the fiber and the "whey" is to incorporate them into a bio-gas or methane production scheme. Bio-gas can be economically produced in many locations where there is a good supply of manure and other organic wastes. The process, which also employs anaerobic bacteria, converts part of the waste to gas that can be used to cook with much the same as propane. The effluent, or slurry left over after bio-gas has been produced from organic wastes, is rich in nitrogen and is useful for improving the structure and fertility of soils. In Nicaragua, part of the residual fiber from leaf concentrate was used to make bio-gas, which in turn was used to cook lunch at the cafeteria of the International School of Agriculture. Bio-gas production can be quite involved and many projects have concluded that it is not economically feasible in their location. However, in some countries, notably China and India, low cost bio-gas units are available and have had some popularity.

It may be possible to use bio-gas to heat the leaf juice in LC projects. A group processing 500 kg of leaf crop per day would produce roughly enough fiber to feed 7 cows and it would need the manure from 9 cows to produce enough bio-gas to the 250 liters of leaf juice to boiling. Only where cooking fuel is very scarce or expensive is bio-gas worth serious consideration.

"WHEY"

We often refer to the clear brown residual liquid as "whey" because of its similarity to the whey that is a by-product of cheese making. Heating the leaf juice is a process quite similar to making simple cheese from milk. In both cases a liquid is coagulated forming curds that contain most of the protein and oils and a clear tea colored liquid. This "whey" is rich enough in nitrogen and potassium to be of some value as a fertilizer. It is deficient in phosphorus, however. The fertilizer value of the "whey" is limited by the fact that it is at least 94% water. This means it must be used very near the leaf concentrate processing site to justify the costs of transporting it to the fields. This problem is even greater when the leaf concentrate is made by the blender method because the extra water used in blending the leaves further dilutes the nitrogen and potassium in the "whey".
The amount of water required by rapidly growing plants is often underestimated. 20-30 liters of water or "whey" are needed each week to supply each square meter of tropical land in maximum leaf production. The "whey" produced as a by-product of leaf concentrate will not be nearly enough to irrigate the land area from which the leaves were harvested. High concentrations of "whey" may damage some tender seedlings. Diluted "whey", as in that from blender processed leaf concentrate, is safe for plants. It is best used for high value crops near the processing site. Obviously, it is a sound idea to wait until the "whey" is completely cooled before pouring it on plants.

Leaf concentrate "whey" is not acceptable in the human diet because of concentrations of nitrates, oxalic acid, and other anti-nutrients. While it has been remixed with the fiber for cattle fodder with good results, watering pigs with "whey" has led to kidney problems over time. Large scale LC operation could possibly justify the expense of evaporating the whey until it was a thick molasses like liquid that could be remixed with the fiber and increase the available nitrogen in ruminant feeds.

It has been suggested frequently that this "whey" could serve as a source of nutrients for growing various beneficial microorganisms like yeast or penicillin. This application requires highly controlled environments to prevent contamination with unwanted microorganisms. These conditions are rarely available in developing countries except in major cities. A project initiated by Find Your Feet in Ghana had some success in producing ethyl alcohol by adding some sugar to the "whey", fermenting this liquid, then distilling it. Production of ethyl alcohol can become very complicated because of government controls or tax policies, or the potential for increasing abusive alcohol consumption.

Dr. Ham Bruhn at the University of Wisconsin suggested an interesting use for LC "whey". He says that pouring the "whey" over the ground will bring angleworms to the surface. This may be a useful trick for fishermen, or those raising worms for soil improvement.
SEEDS AND ROOTS

Immature pods from cowpeas or other types of peas and beans are another potential byproduct of leaf concentrate. Yield of leaf concentrate per kg of leaf crop will decline when the crop begins to flower, but we have found that good quality leaf concentrate can still be made from cowpea leaves after an initial harvest of immature pods. Despite careful planning, often times there will be crops that pass through the ideal stage before they are harvested for leaf concentrate processing. Because of this, there is a real advantage to crops like beans, cowpeas, lablab, or winged beans that have a commercially valuable seed that can be harvested and sold if the plants cannot all be processed for leaf concentrate before they mature.

There are several agricultural situations in which leaves used for making leaf curd would be the byproduct of some other commercially viable product. For example, cassava roots have a broad market but in many locations the leaves are without commercial value. Carefully timed harvesting of cassava leaves can actually increase the yield of edible roots significantly and the leaves could be made into leaf curd. Several vegetables, including cauliflower, broccoli, turnips, and beets have leaves that can be made into LC rather than discarded in the fields or at packing plants.

As with green manure crops and intercrops, it is important not to confuse the primary and secondary objectives of the farmer. If one can get a better yield of the primary product a farmer may be willing to try a new system. Farmers will rarely want to take a reduction in yield in their main crop or an increase in labor, for the sake of an output like leaf curd, whose value may be little known to them.
SECTION IV

ECONOMICS OF LEAF CONCENTRATE

You may know what a kilogram of beans costs, but what does a kilogram of leaf concentrate cost? This is a question that is as important as it is difficult to answer. The cost of supplying leaf concentrate can be calculated as a product like beans, or as a service provided, like health care. In either case, if leaf concentrate is to catch on, it needs to have some economic advantage over competing products or services.

One of the most important jobs of field workers at leaf concentrate programs is to perform ongoing economic analysis. This involves collecting information in quantifiable terms on as many aspects of the program as possible. You may want to start with the wholesale and retail prices of other nutritious foods available in the area. These would often include several types of meat, fish, seafood, cheese, eggs, dairy products, beans, and grains. Powdered milk and dry infant formulas are also useful prices. This will help you determine what the value of leaf concentrate is likely to be, which will in turn help set the price that you will be able to sell it for. There is never a product exactly equivalent to LC on the market so you have to make approximations. The chart on page 90 may be helpful in making value comparisons among nutritious foods. It is important to remember, though, that there is often a great difference between the nutritional value of LC and its perceived value by the local people. The perceived value is what they think it is worth and this will determine the demand for the product. One of the most difficult and important jobs of leaf concentrate workers is educating the population so that the perceived value of LC begins to reflect its nutritional value. When one is selling LC to institutions for nutritional support program the perceived value of the LC should be close to its nutritional value.

Next you will need to gather as much information as possible on the cost and availability of the raw material or leaf crop you will be using. How much will price vary during the year? How much will quality and moisture content vary over the year? Does the price include harvesting and transportation to the field? In some places forage crops, like alfalfa, are normally sold standing in the field. It will do little good to know that an area of alfalfa 3 meters wide by 75 meters long cost $8 US. You will need to calculate how many kg of leaf crop that is, and what it costs to cut it and haul it to the workshop.

After you have a good idea what leaf crop costs you need to gather information on labor costs. What do agricultural workers in the area normally receive for a day's work? How about supervisory workers? What will workers processing leaf concentrate need to earn to make it an attractive idea for them? This may involve some things other than hourly wage. Transportation costs are very important to workers. Will they have to pay for a bus ride or spend and hour walking to work? Fringe benefits are also important in many work situations. Some times workers would prefer earning a lower hourly rate at one job because it entitles them to health insurance or reduced cost child care, or gives them
access to subsidized housing. You need to ask a lot of questions to find out real wages. Sometimes people are reluctant to discuss their incomes, so you may need to work with a trusted local intermediary.

Once you have a good idea what the value of your product (LC) will be, and the costs of raw material and labor, you will need to find out as much as you can about the other costs that are required to produce and distribute the LC. These will include capital expenses and depreciation on capital equipment. Capital expenses generally refer to large purchases whose value is retained for a long period of time. This would include grinders, presses, stoves, cook pots, tables, and improvements to the workshop. Capital expenses are difficult to calculate for many LC projects because often some of the capital costs are donated. Projects that are social service programs may have equipment and other costs met by donation. This can lead to underestimating actual production costs. If $5000 is required to set up a project, the price of the LC should ideally reflect repaying a loan for $5000 plus a normal interest rate. Depreciation is the value lost to wear and tear on equipment. If a grinder costs $1000 and you expect it to need replacement after five years, it means that grinder is depreciating in value an average of $200 per year or about $17 per month. This is another production cost that should be figured in to the price charged for the LC.

Some of the other costs that you will typically encounter are rent on the workshop, electricity, fuel for heating juice, water, and cleaning supplies. Sometimes taxes or registration fees and licenses will need to be paid. There are usually expenses in marketing or distributing the LC that you make. These might include packaging supplies, salaries or commission for salespeople, transportation, free samples, and advertising.

Once you have gathered the basic economic information, you can begin analyzing it. It is often useful to calculate the total production cost of a kilogram of leaf concentrate. Then try to figure how much of that cost is attributable to raw material, labor, capital expenses, fuel, etc. By taking average monthly expenses and production you should be able to get some idea how much the electricity or gas or labor cost for each kilogram of LC. At this point you will be able to see where you should focus your cost cutting efforts. Successful enterprises will eventually eliminate most of their unnecessary costs, but they will start with reducing those costs that are greatest.

Below is a very simple budget broken down for a hypothetical small project, that may help clarify the process of making an economic analysis: * All figures are in US dollars.

### Expenses

<table>
<thead>
<tr>
<th>Expenses</th>
<th>200 kg leaf crop per day</th>
<th>X 250 days of processing per year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leaf Crop</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>= 50,000 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X  $ .06 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>= $3,000 for leaf crop for the year</td>
<td></td>
</tr>
</tbody>
</table>
Transport of Leaf Crop $3 per day
X 250 days $750

Labor $ 9 for 3 workers @ 1/2 day
X 250 work days
=$2,250 labor for one year

Equipment $2000 spread over 5 years
=$400 per year

Gas 330
Electric 120
Cleaning Supplies 50
Miscellaneous 300
$ 800 per year

**TOTAL ANNUAL EXPENSES**  =  $7200

**Income**

Leaf 1000 kg dry LC
Concentrate X $7.50 per kg (equivalent to about $3 per kg fresh LC)
= $7500 per year

Fiber for 22,000 kg
Animal Feed X $.04 per kg
= $880 for one year

**TOTAL GROSS ANNUAL INCOME**  =  $8380

**TOTAL NET ANNUAL INCOME**  =  $1180

This analysis is partly based on several assumptions. One of the most important is that 100 kg of fresh leaf crop will yield 2 kg of dry LC. I've assigned a price of $.04 per kg for the fiber, which is two-thirds the price of the leaf crop per kg. Many dairy farmers may think that the fiber should cost less than the crop because you have removed something of value, namely the leaf concentrate, from the forage crop. In fact, a kilo of the fiber has a feed value roughly 1½ times greater than a kilo of leaf crop, due mainly to the lower water content of the fiber. It is very important that we are able to convince farmers of this fact. Again the difference between perceived value and nutritional value is critical.
Using this hypothetical project we can calculate that it cost $7200 to produce 1000 kg of dry LC. This comes to $7.20 per kg (equivalent to about $2.50 per kg fresh LC). Or:

$3.00 for leaf crop
  .75 for transporting leaf crop
  2.25 for labor
  .40 for equipment
  .33 for gas
  .12 for electric
  .05 for cleaning supplies
  .30 for miscellaneous expenses

$7.20 for 1 kg dry LC

From this one can see that, for example, cutting your electric bill in half would lower per kg costs to $7.14. Reducing crop cost by 15% on the other hand would lower costs to $6.75 per kg. What if you could improve the yield of LC by modifying the equipment and technique somewhat? Suppose you could get 2.5 kg per 100 kg of leaf crop by investing another $1000 in equipment. Then you could produce 1250 kg of dry LC for $7400 ($7200 + 200 extra depreciation each year for the additional $1000 of equipment). This would come out to $5.92 per kg. So increasing the yield is more likely to improve the economics of your project than reducing crop costs or electric consumption.

Cost Analysis from Bareilly, India

Walt Bray gathered the information given below for a leaf concentrate project in India. They should give a more concrete idea how this type of analysis can help. These relationships are specific to conditions in Bareilly, but some will apply generally to other leaf concentrate projects.

**Basic assumptions:** 500 kg of leaf crop at 83% moisture processed per day
  5% yield of 60% moisture LC
  215 kg of fiber sold at the same cost of leaf crop (on a dry matter basis)
  Labor = 4 workers + 1 supervisor
  Equipment cost = $1600 US
  Calculated production cost = Rs 15.6 per kg fresh LC ($0.46 US) *

$0.031 US

**General breakdown of costs**

<table>
<thead>
<tr>
<th></th>
<th>with fiber sales</th>
<th>without fiber sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Crop</td>
<td>12.5% of total</td>
<td>37% of total</td>
</tr>
<tr>
<td>Labor</td>
<td>14.1%</td>
<td>29.6%</td>
</tr>
<tr>
<td>Supervisor</td>
<td>17.1%</td>
<td>12.3%</td>
</tr>
<tr>
<td>Power, and fuel</td>
<td>13.1%</td>
<td>9.4%</td>
</tr>
<tr>
<td>Maintenance and depreciation</td>
<td>16.2%</td>
<td>11.7%</td>
</tr>
</tbody>
</table>
Effect of LC Yield on calculated production cost:

3% yield = Rs 26/kg  
4% yield = Rs19.5/kg  
5% yield = Rs 15.6/kg  
6% yield = Rs 13/kg  

increase of 66.7%  
increase of 25%  
decrease of 16.7%

Effect of fiber sales on calculated production cost:

sale of fiber = Rs15.6/kg  
no sale of fiber = 21.6/kg  
increase of 39%

Effect of daily processing rate on calculated production cost:

250 kg leaf crop/day = Rs 20.6/kg  
500 kg leaf crop/day = Rs 15.6/kg  
600 kg leaf crop/ day = Rs 13.5/kg  

increase of 32%  
decrease of 13%

Effect of leaf crop cost on calculated production cost:

Rs 0.4 /kg = Rs 15.6/kg  
Rs 0.8 /kg = Rs 17.5/kg  
Rs 1.2 /kg = Rs 19.5/kg  
increase of 12.5%  
increase of 25%

Effect of leaf crop cost on calculated production cost (with no sale of fiber):

Rs 0.4 /kg = Rs 21.6/kg  
Rs 0.8 /kg = Rs 29.6/kg  
Rs 1.2 /kg = Rs 37.6/kg  
increase of 39%  
increase of 90%  
increase of 141%

Effect of amount of labor on calculated production cost:

3 workers + supervisor = Rs 14/kg  
4 workers + supervisor = Rs 15.6/kg  

decrease of 10%

decrease of 6.7%

decrease of 16.7%

Effect of capital equipment costs on calculated production cost:

$1500 US = Rs 15.6/kg  
$3000 US = Rs 18.1/kg  

increase of 16%

Effect of bio-gas unit on calculated production cost:

No purchased fuel due to bio-gas unit = Rs 14.9/kg  
All fuel purchased = Rs 15.6/kg  

decrease of 4.6%  

Factors Affecting Dry Weight Value of Certain Nutritious Foods

<table>
<thead>
<tr>
<th></th>
<th>% of food that is normally edible</th>
<th>% moisture content</th>
<th>price multiplier for edible portion on dry weight basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat (beef, mutton, goat, pork)</td>
<td>82.5%</td>
<td>60%</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>52%</td>
<td>67%</td>
<td>5.8</td>
</tr>
<tr>
<td>Fish (non-fatty)</td>
<td>45%</td>
<td>78%</td>
<td>10</td>
</tr>
<tr>
<td>Eggs*</td>
<td>89%</td>
<td>74%</td>
<td>4.3</td>
</tr>
<tr>
<td>Milk (fresh)</td>
<td>100%</td>
<td>88%</td>
<td>8.3</td>
</tr>
<tr>
<td>Milk (powdered)</td>
<td>100%</td>
<td>2%</td>
<td>1</td>
</tr>
<tr>
<td>Cheese (medium soft)</td>
<td>100%</td>
<td>42%</td>
<td>1.7</td>
</tr>
<tr>
<td>Beans (whole dry)</td>
<td>90%</td>
<td>11%</td>
<td>1.3</td>
</tr>
<tr>
<td>Leaf Concentrate (dry)</td>
<td>100%</td>
<td>10%</td>
<td>1.1</td>
</tr>
</tbody>
</table>

* Figure 22 eggs per kilogram.

This chart will give you an idea of the true nutritional value of some common foods that are other purchased as protein sources. Powdered milk selling for $10 per kg is about the same price as fish selling for $1 per kg, or chicken selling for $5.80 per kg once you have figured in the waste and water content. Of course, these foods vary somewhat in their actual nutritional composition, so exact comparison cannot be made. But it is easy to see the importance of calculating in waste and moisture content.

Much of the basic economic analysis for leaf concentrate projects should ideally be carried out before the sites are selected. The more information of this type we have at the start of the project, the greater the likelihood of achieving financial self-sufficiency. There is a series of questions in the section of this manual entitled "Considerations for Setting Up Leaf Concentrate Projects". It is a very good idea to get an answer to as many of these questions as possible before the decision to begin LC production. Even if this is done thoroughly, however, you will need to periodically update your economic analysis to reflect changes in local prices and labor costs.

Up to this point all of the economic analysis has been based on selling LC as a commodity. Another way of looking at leaf concentrate economics is to consider the value of providing nutritional support for malnourished children. This is clearly a service to the community and to the society in general. From the viewpoint of the community or the general society, a well designed program of nutritional support for malnourished children makes tremendous economic sense. Children who are brought up to normal nutritional levels will become far more productive adults than those allowed to remain
malnourished. They will require less expensive medical care, and make much better use of the educational resources your community offers children.

From this perspective our analysis would look somewhat different. The same hypothetical project described on page 87 could supply 670 malnourished children with 6 grams of dry leaf concentrate 5 days a week. If we assume the same production costs of $7200, and the same income from fiber sales of $880; then it will cost $6320 to provide 670 children with leaf concentrate. This comes out to under $10 per child per year, which is an investment many government and international agencies would consider very sound. Of course, there are other costs to providing the nutritional support, but this is often a more attractive way to market leaf concentrate, at least initially, than as a commodity in the open market.

Whether you are offering the leaf concentrate you produce as a product for sale or as a nutritional service, you will have to compete with others offering alternatives. You will need to know not only what meat and eggs and beans costs, but what food supplementation programs and hospital nutrition recuperation programs costs in your community. In either case, it pays to streamline production. If you can find less expensive leaf crop, or a way to improve yield of leaf concentrate, or less expensive machinery, or a better price for your fiber, you will have a more economic project.

**Economics of Very Small Scale Production**

Many times we are asked to help set up very small scale nutrition intervention programs. These programs are often designed to provide nutritional support for the children of one village. Frequently this is fewer than 50 children. The idea is that these programs would be very inexpensive to set up as they would use only hand operated pulpers, such as manual meat grinders, and presses. They would be very decentralized and, at least in theory, very sensitive to local conditions. They may be less encumbered by bureaucratic restraints and administrative overhead than larger programs. Despite these advantages, Leaf For Life does not advocate small programs that use hand operated leaf grinders.

The main reason for this is that a person using a relatively simple inexpensive electric or gasoline powered grinder can grind ten times as much leaf crop in an hour as a person grinding leaves by hand. Hand grinding of leaves is physically demanding as well as slow. Where people are affected by serious poverty and malnutrition, it is a dubious service to introduce an activity that will take up so much time and bodily. By the second hour the worker with the powered machine will likely produce times as much as the one with the hand powered grinder, and the latter is unlikely to be able to last even that long.

If the project uses volunteers, it must accept that the majority of this type of program suffers a drastic decline in volunteer participation after two or three months. If the workers are not being paid and cannot see obvious benefits to their families, they will typically begin arriving late for work and leaving early. Excuses will replace output, and
the aggravation of keeping the volunteer labor force coordinated and enthusiastic will become a drain for most community leaders.

If a leaf concentrate program pays a worker to grind leaves, it cannot afford to pay one who uses a hand-operated grinder. If the worker is paid according to production he makes perhaps one-tenth as much as the more productive worker with a powered grinder. Even after figuring in the lower capital cost of the manual equipment, he is unlikely to earn more than one-fifth as much as the other worker. If he is paid more than that the project is not getting good value for money. If a worker is willing to work for wages that low because of extreme poverty and lack of other economic opportunities, he or she is doomed to a cycle of poverty, because it will be impossible to provide for a family adequately on this income.

If we serve any purpose in introducing leaf concentrate technology to developing countries, it must be done in such a way that peasants can create more wealth from their labor than they are currently able to. People rightly expect "development" to lighten their workload and increase their productivity. This means power tools for physically demanding tasks.

**Economics of Very Large Scale Production**

At the opposite end of the spectrum are very large-scale leaf concentrate operations. There have been several of these over the past twenty years. All have been in industrialized countries and all have used the leaf concentrate primarily for animal feed. The scale of these operations dwarfs the village scale programs established by Leaf for Life. By way of example, France Lucerne, a French firm that processes alfalfa, about 12,000 tons of dried leaf concentrate a year from three plants. The alfalfa comes from about 7000 hectares of alfalfa. They run from mid-April until mid-October at three locations. Each plant represents several million dollars in capital investment. The continuous process is under sophisticated computer control.

Because of their large volume and the advanced technology, France Lucerne can produce dried LC for far less per kilogram than any of the village programs can ever hope to achieve. As attractive as that is, there is a down side to the large scale operations. In the first place they require a great deal of capital that is rarely available in developing countries. They also require a large area dedicated to the leaf crop and a dependable system of transportation to deliver it to the processing plant within a couple of hours. Distributing 12,000 tons of dried LC would also be a daunting task in most developing countries. There is usually a shortage of the highly trained specialized technicians that are needed to run such a plant.

In the US a large plant was built by Atlantic Richfield Oil Company in El Centro, California. I was originally conceived to process up to 60 tons of alfalfa an hour. It was selling dried LC in a pelletized form mainly to the Japanese poultry industry. They used it because it made the skins of factory farmed chickens a more appealing golden color. It also gave the eggs from factory farm a richer looking yolk that customers prefer. When
the Mexican peso was devalued in the early 1980's the price of Mexican marigold meal dropped sharply, and the Japanese began buying it rather than LC to color their eggs. The El Centro plant lost millions of dollars and closed. There are dangers from being too big as well as too small.

MAKING THE BEST USE OF LEAF CONCENTRATE

Leaf concentrate is an excellent food for everyone over 6 months of age, but in most programs production is limited and choices must be made as to where the leaf concentrate will do the most good. Below are some general guidelines on this subject.

- Younger children benefit more than older ones from the same amount of leaf concentrate. Children under 4 and especially those between 6 months and 2 years will show more improvement in health than school age children on a leaf concentrate program. We don't recommend giving children under 6 months leaf concentrate because their digestive systems are still developing and there is a greater likelihood of indigestion.

- Malnourished children benefit far more from feeding programs than children who have normal height and weight for their age. This is very important. Third degree malnutrition (defining degrees of malnutrition is discussed in the nutrition section of this manual) is a life threatening condition. These children should always be given top priority in any nutrition program. It is worth the effort required to go to their homes, talk to their parents, or do whatever is necessary to get leaf concentrate to these children. It could save their lives.

Second-degree malnutrition puts a child at great risk of serious health problems. These children are the next priority. Any nutrition program should try to identify and supplement the diet of all third and second-degree malnourished children in the area being served by the program. It may be worthwhile to get two servings daily to third degree children. They should get 30 grams or two tablespoons of fresh leaf concentrate daily if possible. Second and first-degree malnourished children should get at least 15 grams a day, preferably 20.

- Although weight-for-age records for children are sometimes misleading, it is important to maintain some kind of records on the growth of the children in your program. Many nutritionists feel that weight-for-height is a more accurate indication of nutritional status than weight-for-age. By periodically evaluating the nutritional status of the children in your program, you can get an idea how good a job you are doing. It may also help you to know when a child can be taken off the program to make room for one who is more malnourished.

- It is usually more effective to enrich children's diet at a higher level for a shorter time than to give them a slight supplementation for a longer period. Thus it may be better to give 100 children 30 grams of leaf concentrate daily for 6 months then switch groups,
than to give 200 children 15 grams daily for the entire year. Six months is about the minimum time for a nutrition program to have an impact on a child's health.

- Children showing any degree of night blindness should begin getting 30 grams per day immediately if possible. They should get a vitamin A capsule if they are available.

- Children recovering from injury or illness, especially diarrhea should get 30 grams a day, if possible, in bland foods such as pudding or noodles or soup.

- Children with anemia should get leaf concentrate lemonade or leaf concentrate combined with another source of vitamin C, like guavas, or with a small portion of meat or fish daily until the anemia is reversed. The presence of vitamin C or meat or fish in the same meal makes the iron from vegetable sources, like leaf concentrate, much more usable to the body. You can look under a child's eyelid (with very clean hands) and if the tissue is whitish or light pink rather than red, it is very likely that the child is anemic.

- After malnourished children, pregnant women should receive the highest priority in nutrition intervention programs. They should be offered 40-50 grams daily if possible because of their greater nutritional needs. Since anemia is extremely common among pregnant women, it is also advisable to include a source of vitamin C or small amount of meat or fish with their leaf concentrate. Special care should be taken to get their opinions on leaf concentrate dishes as pregnant women often have strong likes and dislikes for certain foods.

- Lactating or nursing mothers are usually the next highest priority for nutrition programs. They have a particular need for calcium and protein, both of which are well supplied by leaf concentrate.

- If there is an adequate supply of leaf concentrate, adults recovering from illness or injury should next be considered for your program, as should older women who are often troubled with osteoporosis, in which their bones become brittle from too little available calcium.

Two other issues come up frequently when considering how a community can make the best use of leaf concentrate or other nutritional resources. The first of these is the question of intestinal parasites. In many villages in developing countries a majority of the children suffer from intestinal parasites. Some people argue that it is pointless to offer a nutritional supplement because 'you are just feeding the worms'. They argue that the problem is first a medical one, then a sanitation one, and only then a nutritional one. Others say that it does little good to get medicine to expel the worms, because if the living conditions aren't changed the children will be rapidly re-infested.

The problem with these approaches is that it is very expensive putting in good water systems and cleaning up other sources of parasite infestation. In many communities this
is not likely to happen in the foreseeable future. Even the access to the medical care and the drugs used to expel worms is too expensive for a great many people.

While government and other agencies should be urged to begin taking these problems seriously enough to allocate adequate funds; hygiene and sanitation education are inexpensive and can be a part of every leaf concentrate project. Furthermore, studies show that only severe infestations of intestinal parasites affect the nutritional status of children. At the lower levels of parasite infestation that are most common in children, normal health and normal growth are possible with good nutrition. Children with more serious infestations should definitely be treated by local health workers familiar with these problems, if that is possible.

The second issue concerning the optimum use of leaf concentrate or other nutritious foods pivots on the relative merits of central feeding centers vs. feeding the children in their homes. Many health workers feel that the central feeding centers are the only way that you can be sure if the child is actually eating the food offered. They think that the food sent to the child's home is often shared with other family members and sometimes fed to animals.

On the other hand many malnourished children live far from the centers of town. Often the poorest people live the furthest from the resources offered by the town. Young children can't walk a long way on their own and their parents are often too busy with housework, caring for other children, or earning money, to carry them to the centers every day. Sometimes parents are ashamed to send children with no shoes or tattered clothes into the town's center. For these people a program that can deliver leaf concentrate in a preserved state once a week or once every two weeks may be a better option. With a program where the food is eaten at home it is extremely important that someone from the program checks in with the family frequently to encourage them to use the leaf concentrate effectively.

This is a big commitment of labor, and sometimes it is hard to find workers to hike back the muddy trails to these people's homes. Regardless of how it is done, some means needs to be found to reach the children who live on the outskirts of towns and villages or a nutrition program will fail to meet the needs of the community.
LEAF CONCENTRATE AND OLDER ADULTS IN DEVELOPING COUNTRIES

In many societies elderly people are the fastest growing segment of the population. Antibiotics and improved medical care are allowing more people to live beyond the age of sixty even in developing countries where the general standard of living is very low. Older people need the same forty nutrients - carbohydrates, proteins, fats, vitamins, and minerals - as the rest of the population if they are to maintain good health and vigor. Older people, however, do have some special conditions and circumstances that affect how much of these nutrients are needed and in what form they are best utilized.

Some of the factors that can adversely influence the nutritional health of older people in developing countries are:

- **Lack of income to buy food of adequate quality and variety.** Pensions and social security systems to provide for those too old to work are the exception. Most rely on their families to meet their food needs. If that family is poor, food is likely to be preferentially allocated to income earners.

- **Diseases or chronic conditions that affect the eating process.** These can be gastrointestinal disorders that restrict the foods that can be eaten; conditions like arthritis or Parkinson's disease that limit our physical ability to buy and prepare foods; or confusion and memory loss that can cause missed or poorly prepared meals.

- **Dental and mouth pain that make chewing many foods uncomfortable.** Dental and malocclusion problems are very common in most developing countries as professional dental care is nearly nonexistent and false teeth tend to be poorly fitted makeshift affairs.

Leaf concentrate is an inexpensive product that can greatly improve the nutritional status of the high risk elderly population. Leaf concentrate is a very nutritious curd made by heating the juice of certain varieties of green leaf crops. It can be an inexpensive source of high quality protein, iron, calcium, vitamin A and other nutrients in the humid tropics where malnutrition is most prevalent. The soft texture of leaf concentrate makes it a very easy food for people with bad teeth or poorly fitted dentures to eat. Because it can be readily integrated into foods like tamales, dried pasta, and lemonade, that are convenient and easy for older people to prepare and eat, it is especially well suited for prevention of malnutrition among the elderly.

By our mid-twenties the physical performance of our bodies has peaked. Gradually the efficiency with which we chew and digest food declines and we need to eat more of the same foods to absorb the same amount of essential nutrients. Protein, iron, calcium, and zinc are more poorly absorbed with advancing age. Many nutritionists recommend that older people get 12-14% of their calories from protein, as opposed to the 9% suggested for the general population. Often a reduced ability to absorb one or two essential amino acids can lower the quality of the protein in the food older people eat. In areas where the diet is based on staples like corn, sorghum, or legumes that have a marginal quality of protein this can be significant. Where the total quantity of protein is low or marginal, for
example in regions where cassava, yams, or bananas are important staples, impaired absorption of amino acids can lead to protein deficiency.

The body's requirement for iron does not increase with age, (in fact post-menopausal women need less than younger women). However, the reduced efficiency of absorption can cause anemia in older persons with borderline consumption of iron rich foods. The little meat that they can afford is usually very tough and stringy, coming from animals who have not received a rich diet themselves. This is another obstacle to adequate nutrition for the elderly as they very often have great difficulty chewing tough meat due to dental or mouth problems. Dark green leafy vegetables, another source of iron, are quite fibrous and can also be very hard to chew thoroughly for people with poorly fitting dentures or missing teeth.

Calcium is another essential nutrient that is more poorly absorbed with advancing age. Dairy products are an excellent source of calcium, but they, like meat, are usually too expensive for low-income elderly in the tropics. Perhaps even more limiting than price is the fact that the majority of elderly people in the world cannot digest lactose, or milk sugar, very well. Most adults can consume a small amount of milk (less than ½ liter per day) without difficulty, but larger quantities can cause uncomfortable gas formation, bloating and diarrhea (the main exceptions to this being people of northern European ancestry and some African tribes with long histories of cattle herding). Cheese and yogurt don't usually cause this reaction because the fermentation process breaks down the lactose. For more information on lactose intolerance please see the chapter on Discussion Topics.

Dark green leafy vegetables are potentially an inexpensive source of calcium for these people. Greens have several limitations as food for elderly people in developing countries. As mentioned earlier, they are difficult to chew because of the high content of tough fiber. Many greens contain oxalic acid which can block the body's absorption of calcium.

Older people generally need fewer calories from their diet than their younger counterparts. Usually the amount of time spent in demanding physical activity is much less. Even in times of rest the body of a 70 year old typically uses about 10% less energy than when he was 20 years old. It is quite possible for elderly people to simultaneously suffer from being overweight and undernourished. For example, in parts of Mexico fats, mainly lard, and sugars which supply only calories, make up a large and growing part of the diet. With their decreased need for energy and reduced absorption of many other nutrients, older people can easily put on excess weight without assuring their other nutrient requirements are met. Because leaf concentrate is extremely rich source of a wide variety of nutrients and has an average calorie content, it is an excellent nutritional insurance for older people.

As a person grows older their immune system, like their digestive system, becomes less efficient. Older people are more prone to infections than younger adults. Infections are closely linked with nutrition. Malnutrition increases our susceptibility to infection and
infection increases our nutritional requirements. Vitamin A is especially important in preventing infections as it helps to maintain the effectiveness of mucous membranes in the respiratory and digestive system, which is the body's first line of defense against invading micro-organisms. Leaf concentrate is the richest known source of beta-carotene which is converted to vitamin A within the human body. There is some danger of toxicity from overuse of high potency vitamin A capsules that are often distributed by clinics and development groups. Beta-carotene, on the other hand, is a non-toxic way to insure adequate vitamin A in the diet.

In summary, leaf concentrate is an inexpensive food that is extremely rich in several of the nutrients most likely to be lacking in the diets of elderly people in developing nations. Leaf concentrate is easy to combine with inexpensive staples, and a wide variety of these combinations have proven acceptable in various cultures. Most of these foods are very easy to chew and digest compared to local alternatives.

Some resources for nutrition and the elderly:

* Nutritional Care of the Older Adult  Annette B. Natow and Jo-Ann Heslin  MacMillan press NY 1986  306 pp

* Nutrition Screening Manual For Professionals Caring For Older Americans  Nutrition Screening Initiative  Washington, DC  1991


* Nutrition Assessment: A comprehensive guide for Planning Intervention  M. D. Simco, C. Cowell, and JA Gilbride  $35
  Aspen System Corp.  1600 Research Blvd.  Rockville, MD 20850

* Nutrition of the Elderly  Ed. Munro and Schlieref Nestle Nutrition Service  Raven Press
  1185 Avenue of The Americas
  NY, NY 10036  1991
CULTURAL ASPECTS OF LEAF CONCENTRATE PROGRAMS

Leaf concentrate doesn't do any good if people don't eat it. Whether children will eat leaf concentrate or not depends on many cultural factors. How the leaf concentrate is presented and how it is distributed play an essential role in any leaf concentrate program. This manual contains a few recipes that should give community workers some ideas as to how to incorporate leaf concentrate into traditional dishes. Peoples' tastes vary from region to region and the recipes will always have to be adjusted for this.

A public dinner to introduce leaf concentrate to a community can be very helpful if several dishes are attractively presented. If the women in your community are reluctant to get involved with the project you might try a cooking contest to see who can make the best recipe containing leaf concentrate. If a local judge or panel of judges can be recruited from well-known local people and the contest connected with a community celebration of some type it may help gain interest and acceptance for leaf concentrate.

The method of distributing leaf concentrate to malnourished children in your community should be given a lot of consideration. Often the most seriously malnourished children live far from the community center. Their parents may be very busy, or discouraged, or sickly, or ashamed of their appearance. Any of these can lead parents to avoid bringing their children to breakfast or other feeding programs. Sometimes the fathers of malnourished children feel that if their children are in a nutrition program, it is an admission of their inability to provide for their families. Maintaining pride is of great importance. Generally speaking, the more the program appears to be a charity for the poor, the more social stigma is attached to it.

The ideal approach is often to provide nutritional education to the parents while at the same time appealing directly to the children. Sometimes a few balloons or small toys can generate a lot of interest. If attendance is not consistent at a feeding center, a weekly prize of some kind could be given away in a lottery open only to children who have attended every day that week. If a video cassette player is available, perhaps one day a week a children's movie could be shown while atol or churritos or some other leaf concentrate snack are fed. If it is made fun for the kids the parents will be more enthusiastic and half your work will be done.

Families with malnourished children often
have a lot of problems. Sometimes alcohol or drugs, or learning disabilities, or emotional problems prevent people from taking good care of their children. Sometimes the problem is just economics; the lack of adequate income. Whatever the case, it is very important that they be treated with respect. It is also important that nutrition workers don't give up on families with malnourished children, even if they are ungrateful and uncooperative. They may be cynical about these types of programs, perhaps with good reason, and it may take several home visits to convince them that you are for real.

The broader the base of support you have in a community the greater the chance of the leaf concentrate project taking root. It is always a good idea to try to get the doctors and other health workers in the area interested in the project. If you can enlist social service workers in the area or university students doing their social service work, they often have a lot of enthusiasm. Most often, however, a group of local mothers is by far the most important support group for these programs.

There are no fixed rules for introducing new foods. The best you can do is to pay attention to what the local people say and feel, and to learn from your own mistakes and those of other groups doing similar work.

**THE COMMERCIAL MARKET**

While most of this manual has focused on the use of leaf concentrate to improve the nutritional status of young children, we are also aware of a great deal of interest in small-scale marketing of leaf concentrate products. Leaf For Life is working with small women's co-operatives in several countries that are trying to generate income through the sales of leaf concentrate products. Most of these co-ops have a dual motivation of trying to improve the diet of local malnourished children, while, at the same time, earning a basic salary or wage for their labor.

The requirements for successfully marketing leaf concentrate products are very different from those of a successful nutrition intervention program. The biggest difference is in the targeted consumer. In nutrition programs we are mainly trying to reach young children whose parents are poor and often quite uneducated. In marketing leaf concentrate we frequently find ourselves targeting well-
nourished, well-educated, middle class urban people who have recently become concerned about health and nutrition. This "health food" market tends to be small and very fussy, but willing to pay high prices for foods they feel will improve their health. There is often a huge mark up on the prices of foods sold through 'health food' shops because the volume of sales is small. This means that even though the price to the consumer is very high, the price to the producer may not be. Sometimes these shops are unwilling to carry products containing salt, refined sugar, or artificial flavors. At the other end of the market, efforts to market leaf concentrate foods in low-income communities, revolve around a low enough price and acceptance of a new food.

It may be helpful to relate some of the experiences of the La Casa de la Salud women’s co-operative in northern Mexico as they tried to market leaf concentrate products in nearby villages and in the city of Mexicali. After 2 years of producing a small quantity of leaf concentrate foods for their families and neighbors in their village of about 2000 people, they decided the only way their project could continue was through the sale of products.

Many of the leaf concentrate foods that had been eaten in their village, like puddings, frozen confections, donuts, and meat substitutes were considered as possible products for local markets on a small scale. However, their short shelf lives made them inappropriate for larger scale marketing in Mexicali. After a period of test marketing several products, the co-op decided to focus their sales efforts on three; dried pasta, syrups for making lemonade and other drinks, and fried corn snacks, called churritos.

Each had advantages and drawbacks. The pasta was attractive, convenient and stored extremely well, but per hour production output was very low because a hand operated machine was used to make it. The drink mixes required much less labor, as they could be made in a kitchen blender by combining leaf concentrate, lemon juice and sugar. The bottles and labels needed to package this sticky liquid on a small scale, however, were quite expensive. Churritos were very popular with children and teenagers and were well suited for giving out as samples, as they are ready to eat. Because people seem quite willing to accept novelty in snack food, it was far easier to get people to try churritos than pasta, which had to be planned into a conservative meal pattern. The churritos had a shorter shelf life than either the pasta or drink mixes and there were some quality control problems. Fluctuations in moisture content, oil temperature, and frying time made it difficult to get a uniform product. Some churritos were too hard, others too greasy.

Having chosen three products to sell, the next steps were to promote them in Mexicali, and to find ways to make them more efficiently, thus lowering per unit costs. The co-op had attractive labels printed for all three products. A pegboard product display was designed and given free to storekeepers willing to try selling these new products. Stacks of free flyers explaining the value of leaf concentrate were left for customers at each store. Articles about the co-op and their products were submitted to local newspapers and a representative went on a local radio show to raise public awareness.
On the production side, steps were taken to increase output, lower costs, and improve quality. A larger commercial blender helped with drink mix production and an improved rack sped up the drying of the pasta. A nylon dieplate replaced the steel one in the churritos maker, which made for smoother churritos that absorbed less of the expensive oil. Bulk purchasing of corn meal, cooking oil, sugar and other supplies lowered costs. The factor most limiting to production, however, was the low output of leaf concentrate itself.

'La Casa de la Salud' has not been able to become a profitable co-op selling leaf concentrate products yet. Problems of irregular supply of leaf crop, low hourly output of leaf concentrate, and difficulties in transporting the products to market are large obstacles that haven't yet been overcome. The co-op has not been able to get stores in the low income barrios of Mexicali or neighboring villages to carry the products regularly. Volume of production is so small that only the very high retail prices charged at the middle class health food stores, hold promise of providing a steady income to the women. And of course, these are the people who least need nutritional support.

Before dismissing the co-op as a failure, however, it is important to remember that they were never purely a business venture. In addition to running a profitable co-op the women wanted to take effective action against the malnutrition that is prevalent in their area. Approximately 25% of their production was donated to poor families in their village and to primary school children in a very run down barrio of Mexicali. The co-op also helped to meet several social needs of the women and their families. Much of the appeal of the co-op to its members is that it offers part time work in the village, so that family life is not severely disturbed by the women seeking additional income. The women arrange their own work schedules and their young children can play in the adjacent churchyard during their 3-4 hour shifts. The co-op has a fund set aside to help members with emergency expenses. Most of the other employment opportunities for women have long inflexible hours and transportation problems.

Despite these social benefits to the women and the community, the co-op is in serious trouble. Our experience with marketing elsewhere has been similar. It is extremely difficult for a small democratic co-operative making a new product to compete with large mechanized, well-financed food companies. From the hard cold viewpoint of business the social benefits to the community are often just an unacceptable overhead. Regardless of the difficulties involved, successful marketing of leaf concentrate is essential if this food is to play a significant role in feeding future generations. Below are a few points that any group thinking about marketing leaf concentrate products might consider before getting started. These aren't intended to discourage people, only to offer some realistic perspective on the food business.

- **The importance of selling products and difficulty of doing it are always underestimated.** In most businesses sales workers are paid far more than production workers, yet co-ops often view sales as a very secondary part of their operation. Women in leaf concentrate co-operatives often see the work as an extension of the cooking and feeding they traditionally do at home, and as such they are quite familiar with it. The
aggressiveness required of sales workers is often uncomfortable for village women. Good sales people have real skills and talents that shouldn't be taken for granted. They understand people. They are creative, enthusiastic and persistent in the face of repeated rejections. They are a tremendous asset to any group trying to market leaf concentrate products.

- **You will need to put some money into getting things rolling before you begin making a profit.** Small co-ops often balk at spending their precious money on things like advertising and promotion. Business people understand that, especially when introducing new products, substantial effort has to be put into giving the product away before it can be sold profitably. You will need to plan on expenses like free samples, product displays, contest prizes, and radio advertising to launch your business.

- **Quality control is essential.** If you are selling pasta, don't try to sell the bags with lots of broken pieces. Make sure your products look beautiful, not just OK. Someone who buys one bag of churritos that are hard or have a burnt flavor is unlikely to ever buy them again. You are responsible for making sure your products are not being sold in stores when they are too old. Be sure that your bags are not sealed in such a way that people might end up with a staple in their mouth. If your bags say they contain 100 grams, make sure they do.

- **Be conservative in your financial calculations.** 10 kgs of ingredients will never make 100 bags of products with 100 grams in each. Some of your products will always be lost through spillage. Some prepared foods will usually be broken or burned during processing. If your foods are tasty and ready-to-eat a surprising amount may be eaten by workers before heading to market.

- **Some unexpected expenses should be expected.** All of your equipment as well as your building will need periodic maintenance and eventual replacement. It is better to slightly overestimate your costs and be pleasantly surprised, than to fail to meet unrealistic expectations. Dig in for the long haul. Most successful food businesses lose money for at least their first year before becoming profitable.

- **Take advantage of available resources.** Many governments have set up agencies to help small co-ops and businesses get started. There are a growing number of non-governmental organizations that are promoting small worker owned businesses as a way out of poverty. Some of these, like the Grameen Bank in Bangladesh, offer small loans with low or no interest. Others can offer help with teaching workers unfamiliar skills like accounting, marketing, or equipment maintenance.
THE SOCIAL MARKET

The line between business and charity is often blurry and getting more so every day. Increasingly development agencies are interested in supporting projects that will one day become self-supporting small businesses or micro-enterprises. The problem is that it is very difficult for a small women's group to become a profitable business by selling a new product (LC) to a group of people who are notoriously impoverished, namely malnourished children. The need to become financially self-sufficient can have some interesting effects on small groups. Groups that started with the honorable intention of reducing childhood malnutrition in their community, often end up with the dubious objective of selling rich people LC at the highest possible price.

We have moved into an arena sometimes called the social market in an effort to resolve this contradiction. Broadly speaking, social marketing is selling products or services through organizations or institutions that are trying to perform socially beneficial services. These include orphanages, clinics, old age homes, schools, homeless shelters, feeding programs for malnourished children, refugee support programs, and a range of other programs set up to help out societies more vulnerable members. For the most part these are programs that need to provide the essential nutrients to groups of people under their care. Because they need to regularly buy nutritious food in large quantities they could be an ideal market for leaf concentrate in many ways.

Selling LC to them is quite different than selling it in the commercial market. Typically, these institutions have very tight budgets and need to buy food at low prices. However, they are often sympathetic to some of your group's objectives. They may want to help support your women's co-op by buying LC because they agree that the income generating possibilities for village women is linked to the problem of poverty that they are working on. They may like the idea of using local resources and paying local workers for the production instead of bringing in imported foods. On the other hand, you may be competing directly with food that is given away for free by the World Food Program, the government, or the church.

Besides being able to reach people who really need the LC, the biggest advantage of social marketing is that some of these institutions serve a lot of people and need a lot of food. They can buy large quantities of LC. For example, we are negotiating with a group called Alianza Urbana (Urban Alliance) in Mexico. They run 82 barrio feeding centers. Soynica in Nicaragua is running 26 centers with an average of 85 children and mothers in each. This is 2200 people or far more than you are likely to reach by selling to a handful of small retail shops. A once a week snack for thousands of school children could absorb all the production from a small LC production coop. We are just beginning to learn how to do effective social marketing, and have a long way to go. Below are a few points that have been helpful so far:

1. **Calculate the lowest price that its is worth selling your LC for.** If your price is too high you won't interest the social institutions, if it is too low you won't recover your operating costs. It is hard to raise prices once they are set.
2. **Sell dried concentrate or simple LC foods that have a long shelf life.** Most institutions have their own kitchen staffs and will not want to pay you the additional labor costs of preparing more complex foods like churritos. Dried LC enables you to deliver a sack every three weeks instead of delivering perishable fresh LC every two or three days. This reduces the cost of transportation.

3. **Make a list of all the social institutions in your area.** Include address, telephone number, and contact person. Arrange these in the order of those you think most likely to purchase LC first and least likely last. Begin at the top of the list visiting the institutions, meeting the directors and dropping off information about LC and your project. Leave some samples of both dried LC and of at least one appealing local food that can be made from dried LC.

4. **Arrange a return visit with free samples of an LC food.** If the institution is not too large, bring enough for everyone to try it. Directors are far more likely to allow you to bring something for a midmorning snack than for a meal, because the meals often have menus that have to be approved by someone beforehand. This should be short, fun and informative. Green frog cookies for children or green Christmas tree cookies at Christmas time are good for getting people interested. Take photos if possible.

5. **Offer to send someone from your project to help the kitchen staff learn to cook with LC.**

6. **Ask the director to consider buying a small but definite amount each month.** If they would like to buy LC and feel that it would be a benefit to their institution but can't afford, ask them to write you a short letter expressing their interest. You can then approach social clubs, churches, etc. with this letter asking them to help the institution purchase a local high nutrition food.

7. **Ask for testimonials from institutions that have used LC for a while.**

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**MARKETING FIBER**

Make every effort to find a market for the leaf fiber you produce. If you cannot sell it to dairy farmers for cash, perhaps you can arrange a trade of your fiber to someone raising animals for some service or product that would help your business. Again, with an unfamiliar product you may have to give it away for a while to convince people that it is worth buying. If you can interest an innovative and successful farmer in using the fiber, his endorsement may make it easier to sell to others. Similarly, if you can get a local university of agricultural school to test the feed value of the fiber (with donated fiber), it may be easier to get the attention of farmers.

If you have the space it may be worthwhile drying or ensiling the fiber so that it can be stored and sold at a time when livestock feeds are at their lowest levels and highest prices. Another alternative is for the project or cooperative to raise its own animals for
sale feeding them with the fiber. This substitutes a known commodity (the animals) for one of unknown value (the fiber). This can be a sound financial strategy if the people involved in the project are familiar with raising the animals and feed for the animals is expensive enough to justify seeking lower cost alternatives. It can get complicated having joint ownership and responsibility for animals.
SECTION V
DISCUSSION TOPICS

The purpose of this chapter is to familiarize LC workers with some of the controversial topics that sometimes come up when one is working on LC programs. For the most part there are no definitive answers to the questions posed here. The aim is simply to present a quick background and some useful perspective on questions that many volunteer field workers and staff people have encountered. It is beyond the scope of this manual to explore these issues in the depth many of them deserve. These are arranged in three groups; production issues; nutrition issues; and the bigger picture.

Production

"Should we be practicing organic farming methods?"

"Organic farming" generally refers to raising crops and animals without the use of synthetic fertilizers or pesticides and herbicides. There are many closely related concepts like regenerative farming, bio-dynamic farming, natural farming and sustainable agriculture. Underlying them all is the idea that farmers must take good care of the soil and that a healthy soil will produce healthier plants which will be more able to take care of themselves. Much of the initiative comes from consumers who feel that modern agricultural techniques produce food that is tainted with pesticides. Increasingly, the organic agricultural movement is driven by concerns about the environmental contamination and high energy costs of modern farming. There is almost always present a philosophical element as well. This boils down to the idea that humans need to remain close to the natural cycles of life and that industrialized agriculture turns the living biological relationship of food production into a mechanical one.

Many people become interested in leaf concentrate through their involvement with organic gardening, health foods, vegetarianism, or other aspects of what might be called a search for a more natural way of life. Sometimes these people become disillusioned with leaf concentrate projects when they find out that we may use leaf crops grown with chemical fertilizers or pesticides.

Everyone has their own lifestyle and their own views, but it is helpful to try to keep some perspective when working with leaf concentrate programs in developing countries. The idea of "organic gardening" evolved in wealthy nations as a response to perceived problems in industrialized food production, after they were producing large food surpluses. Most of the developing countries only have industrialized agriculture for export crops, and suffer from inadequate production levels of basic foods. Much of the wisdom of the "organic agriculture" movement is tied to conditions in the temperate climatic zones where it evolved. In hot tropical climates many of the organic strategies don't work nearly as well. For example, composting which is central to organic
agriculture is vastly less useful in the tropics because nitrogen is lost to the air so much more quickly.

Organic farmers advocate using the slow acting rock phosphate, rather than the synthetic super-phosphate for soils deficient in that nutrient. However, tropical soils are far more likely to be deficient in phosphorus and transportation is typically so much more expensive, relative to income, that the hauling of low value rock phosphates makes less sense than it does in the US. The question of pest control is also quite different in the tropics where there is no long cold winter to depress insect population and freeze out soil nematodes. "Organic farming" approaches tend to be long term solution like building up the humus level in the soil or gradually bringing pest and predator populations into equilibrium. The logic of these strategies is essentially unchallenged. The difficulties of implementing them in terms of leaf concentrate projects are several.

Very often we are operating under the terms of a two-year grant, and need to show measurable results within that time. Sometimes the land being used is on a short-term lease or the tenure is very insecure. This makes it difficult to encourage people to make the long term investments in soil building. Our primary objective is generally to improve the nutritional status of the people, especially children, in the area of the project. Agricultural innovations are necessarily secondary to this objective. When there is a conflict, for instance a leaf crop will be lost to insects unless pesticides are applied immediately, we are obliged to take measures to protect the crop. This is not a hypothetical situation. it happens often in practice.

If we are not in a position to impose "organic" orthodoxy in our projects, neither can we completely ignore the essence of the "organic" message. For a range of economic, environmental and health reasons we need to use the most "organic" methods that are appropriate to a given situation. If agriculture is dependent on huge energy subsidies or is rapidly degrading the resource base that it operates from it is not sustainable. If its not sustainable, its bad agriculture. Leaf for Life is part of a growing movement towards low input and low impact agriculture that is not based on doctrine, but rather on observation of specific conditions. We need to be aware of the full range of available responses to crop problems and choose those least likely to cause damage. For example, we have planted neem trees at one of our production sites in Nicaragua because the neem seeds can be made into a safe, effective low cost insecticide. Sustainable agriculture is a direction to move towards not a set of prescribed practices.

"Should we encourage the production of animals for meat in leaf concentrate projects?"

More people than ever before are questioning the wisdom of raising animals for meat. The doubts come from concern over the ethics of our relationship with animals, and perceived nutritional and environmental problems related to the production and consumption of meat. As with the arguments for "organic" agriculture, most of these viewpoints developed in industrialized temperate zone societies that didn't suffer from
food shortages. Many people have chosen to become vegetarians (eat no meat) or vegan (eat no meat, eggs, or dairy products) in response to these concerns.

The argument against meat is strongest when aimed at the US feedlot beef production. Huge quantities of edible food (mainly corn and soybeans) are fed to fatten cattle held in cruel confinement. The fatted cattle then provide heart disease and cancer for the overfed people who eat them. In the tropics very little humanly edible foods goes to animals. They are seen much more as a means of converting less valuable resources like the tough tropical grasses on poor rangeland and domestic garbage into a valuable food. Where protein-energy malnutrition is common and anemia is widespread, the highly digestible forms of protein and iron in meat, even in small quantities, can be important to the diet.

Ruminants like cows, goats and sheep can convert indigestible cellulose fiber to useful foods for humans. With few exceptions the most economical use of the fiber remaining from leaf concentrate production is to use it produce milk or meat from ruminants. There are other possible uses for this fiber, such as improving the soil, making bio-gas, or making paper, but none compare to animal feed in economic value to the producer. Beside the value of meat or milk, animals also serve as a source of power for agricultural work and transportation in many developing countries. When trucks and tractors wear out new ones must be bought, but horses and cattle can reproduce themselves. This point is very important to impoverished farmers. The manure from farm animals is also important for maintaining soil fertility. Some groups we work with may elect not to raise animals with the leaf concentrate fiber for various reasons. Whether to raise animals should be decided by the local group after they have been well informed about the alternative uses for the leaf concentrate fiber.

"Shouldn't the processing of leaves be continuous rather in batches?"

There are two basic approaches to leaf concentrate processing; Continuous Processing and batch processing. Continuous processing allows for the uninterrupted flow of materials from the time the leaves enter the workshop until the leaf concentrate is separated. It is the type of system normally used in most industrial processing, and can be very efficient in terms of output per hour of labor.

When the leaf concentrate is made by repeated steps with breaks in between, it is a batch process. So, for example, if you have 200 kg of leaves to pulp and you feed it through a hammer mill it is a continuous process. But when you pulp it 3 kg at a time in a blender it is a batch process. A belt press allows for continuous processing, but a lever press or jack press handles a batch at a time.

One part of the process could be continuous and another part batch. For example, in Mexico we use an impact macerator that allows for continuous pulping, then a batch type hydraulic press table and a batch type cooker. The advantage of continuous processing is lost if any part of the process is done by batches, because the material flow will have to stop and wait for the batch processing.
With the obvious advantages of continuous processing, why do we ever use batch processes? Continuous processing often require more engineering to make sure all the parts of the system are matched for speed. If your hammer mill processes 500 kg per hour but your belt press can only handle 200 kg per hour you won't have an efficient continuous process. When you are dealing with a relatively small volume of material, say less than one ton of leaf per day, the initial costs of designing an efficient continuous process leaf concentrate system may not be justified. The highly variable conditions of work one frequently encounters in leaf concentrate production in developing countries can also make managing a coordinated system very difficult. Often the quantity and quality of the leaves will vary greatly from day to day as may the number of workers. Even the voltage of the electricity can vary considerably. If anything goes wrong with a continuous process the whole system comes to a halt, whereas with batch systems it is often possible to keep processing by making modifications only in that part of the process that is going wrong. Batch systems tend to be simpler, more flexible, and less expensive to set up than continuous systems. Conditions in developing countries are usually such that flexibility is an enormously valuable characteristic in a processing system. The great advantages in efficiency of continuous systems probably come into play at a rate of about one ton per day or more.

"Shouldn’t food processing equipment be made of stainless steel?"

In most developed or industrialized countries there are rigorous health codes that determine what materials may come in contact with food during processing. Stainless steel is the standard for most food processing equipment where these codes are in force. It is extremely resistant to rust and can be cleaned very thoroughly. The problems with using stainless steel equipment in nutrition programs in developing countries are threefold; it is expensive; it is hard to find; and it is hard to work with.

When stainless steel is not available or is too expensive for a project, what alternatives can be used? We frequently use plastic containers of various sizes. They are relatively inert and can be cleaned well unless they are badly scratched. Polyester and nylon cloth are often used to replace expensive stainless steel screen. They are quite inert and can be cleaned but will break down more quickly from abrasion or friction. Some synthetic cloths and plastics will photo-degrade or gradually break down from exposure to ultraviolet radiation sunlight. Some plastic are certified food grade even in wealthy countries.

Wood is a traditional material used in food processes. It is often employed for chopping boards, rams for pushing leaves into grinders, feed chutes, pressing and drying frame trays, etc. Increasingly we have been using non-toxic wood sealer, such as salad bowl sealer to protect wooden equipment used in our processing. This should reduce bacteriological contamination.
Sometimes galvanized sheet metal is used in trays and washtubs. This is steel plated with zinc. It should not be used where the zinc will be quickly worn off or where strongly acidic substances stay in contact with it for more than a few seconds.

Mild or rolled steel is used when great strength is needed, for example in the frame of the press tables or the legs of the macerator. Mild steel rusts quickly when it is exposed to water or even damp air. For the most part rust is not a dangerous contaminant. In fact, it can contribute useful amounts of iron to the diets of anemic people. When a steel surface becomes rusty, however, it is much more difficult to clean and the pocked surface creates hiding places for bacteria. Rusty steel also is visually unappealing and this is quite an important consideration when you are trying to convince someone of the value and safety of an unfamiliar product like LC. Aluminum is used in cook pots for heating the leaf juice and sometimes in other processes. Its limitations are described below.

Some rules of thumb for making sure your processing equipment is safe and appropriate.
- Check with local health codes and visit similar food processing shops in the area.
- If stainless steel is available and you can afford it, use it in preference to other materials.
- Make certain that your equipment is designed so that there are not impossible to clean places where harmful microorganism can breed on food particles.
- Use material that won't easily chip or wear off.
- Make sure the leaf juice is brought to a full boil to kill any bacteria that may have gotten on the leaves or equipment.

"Is cooking in aluminum pots bad for you?"

Some people have expressed concern about contamination from aluminum cookware. Some evidence shows a possible link between high levels of aluminum in the diet and Alzheimer's disease. Cooking very acidic liquids such as tomato sauce in an aluminum pot for an extended time could cause some metal to be dissolved. This should be avoided. If the inside of the pot is very rough textured, or if it is scratched up from scraping with a metal spoon or from cleaning with a metal scouring pad aluminum is more likely to leach into food because of the increased surface area of the metal. The juice from most leaves that would be used in this process is slightly acidic (pH 5.6 - 6.4). This is not acidic enough to cause any problem. A smooth finished heavy gauge aluminum pot should not contaminate juice at this acidity heated briefly to the boiling point. It is a good idea to avoid vigorous scraping of the bottom and to replace these pots when they become very scratched.

There have been cases of zinc contamination from very acidic foods being cooked for long periods in galvanizad cookware. Antimony poisoning has occurred where acid foods have been cooked in chipped enamel cookware. Both galvanized and enamel pots should be avoided for heating leaf juice repeatedly in leaf concentrate programs.
Nutrition

"If people get enough **calories** in their diet, won't the protein **take care of itself**?"

In the 1950's and 1960's there was a general focus on the lack of protein in diets of people in tropical countries. Numerous schemes were developed to introduce protein enriched foods and drinks into populations where malnutrition was prevalent. Weaning foods like INCAPARINA were introduced with carefully formulated amino acid balance to increase protein intake in low-income families. There was generally a lot of research on alternative protein sources done by governments, universities, and food companies like General Foods, General Mills, and Coca Cola. Fishmeal from dried Peruvian anchovies was advocated as a solution to the world's protein deficiency, as were single celled proteins grown on petroleum refinery byproducts. Chlorella algae grown in illuminated clear plastic tubing was promoted as a substitute for producing protein food on land. Leaf concentrate, which was then called leaf protein, was very much a part of this worldwide search for a means to close the perceived "Protein Gap".

Around 1972 several studies came out suggesting that protein requirements had been overestimated and that a shortage of energy or calories in the diet was a far more common problem. It was argued that as long as one was receiving an adequate amount of calories, that protein would take care of itself. That is, a person eating a tradition grain based diet would take in enough protein as long as he got enough calories. As this point of view became the consensus opinion of nutritionists and development agencies, interest in novel sources of protein, like leaf protein quickly diminished. It was replaced by a passion for calories and to produce more grain. All people needed was "more of their traditional diet".

This change in outlook roughly coincided with what has become known as "The Green Revolution". This was a worldwide revolution in the production of grain led by the development of high yielding short-stemmed wheat and rice varieties in Mexico and the Philippines, respectively. The new hybrid grains did indeed produce huge crops, and created some optimism that hunger would be soon defeated by plant breeding science. The "Green Revolution" crops required far more in the way of fertilizer, pesticide, machinery, and irrigation than the older grain varieties. By the 1980's grain yields were reaching a plateau. Any further increase in yields was coming only from proportionately greater inputs of fertilizer and energy.

A major unintended consequence of the introduction of the high yielding varieties was a dramatic decline in the consumption of peas and beans in many countries. The large farmers who could afford the inputs diverted land that had been growing peas and beans to produce the more profitable new grain varieties. This reduced the supply and increased the price of these foods, which have traditionally been a vital source of protein in many cultures. In India, for example, per person consumption of peas and beans declined by half between 1970 and 1985.
In 1993 few people believe the "Green Revolution" can answer the world's hunger problems in the long term. The leading role of calories and the need to simply "eat more of the traditional diet" continue to dominate nutritional development thinking. However, nutritionists are beginning to see the traditional diets changing rapidly in many areas, powered largely by rapid urbanization in the tropics. Highly processed and heavily promoted convenience foods are being eaten in quantities that must be considered in terms of nutritional impact on millions of people. The importance of vitamins and minerals, collectively called micronutrients, is also increasingly being stressed. No one claims these requirements will automatically be met if calorie needs are met.

It is very unlikely that we will return to the days of "the Protein Gap", but it is important to maintain some perspective as waves of revolutionary nutritional studies are reported in the popular press. It is a time of great interest in nutrition and impressive strides are being made in our understanding of this science. You should read reports about new nutritional information carefully. Often these are "preliminary findings" based on tiny samples of people. Amid the flurry of reports, consensus of informed opinion will gradually form.

"Wouldn't people be better off just eating more dark green leafy vegetables than making leaf concentrate?"

The health giving value of greens, such as kale, spinach, turnip and mustard greens, in the diet is almost universally known, yet hardly ever are they eaten in adequate quantities by children at risk of malnutrition. Very rarely can projects geared towards promoting gardening show an improvement in the health of the children in the area.

Greens contain a lot of fiber. Adding fiber to the diet is important for many adults who eat highly refined diets. Children in developing countries, however, usually get plenty of fiber from the grains and beans and fruit in their diet. The high fiber content of greens can aggravate diarrhea and reduce absorption of iron in these children who frequently suffer from both diarrhea and anemia.

Although they are productive and easy to grow, greens tend to be very perishable and difficult to market because they are usually 85-90% moisture. In the heat of the tropics, where most families don't have refrigerators, greens last only a day or two before becoming inedible. Because so much of the weight of greens is water and indigestible fiber, they are often quite expensive as a source of nutrients.

Children frequently don't like the strong flavor of many greens and won't willingly eat them in many cultures. The strong flavors are often attributable to antinutrients like nitrates, oxalic acid, tannins, and saponins. These antinutrients should not be consumed in large quantities by anyone, especially malnourished children. The leaf concentrate processing removes most of these antinutrients, nearly all the fiber, and the bulk of the water in greens, making it generally more acceptable and more nutritious than the greens it is made from.
"Wouldn't it be cheaper and easier to **fortify** common foods with nutrients that are in short supply?"

Often there is disagreement among nutritional workers on how to best correct a nutrient deficiency in a given population. The approaches will range from giving capsules or tablets of the nutrient to encouraging people to produce and eat more traditional foods that are rich in the missing nutrient. Some success has been achieved by fortifying a common food with the missing nutrient, such as the fortification of salt with iodine. Focusing on vitamin A deficiency, a consideration of capsules and fortification is given below and they are compared with leaf concentrate as a vehicle for countering the deficiency.

**High Potency Vitamin A Capsules:** These are very effective at rapidly reversing deficiency symptoms. They are relatively inexpensive and very compact for easy transport into remote areas. The capsules also tend to have the affect of turning a food and nutrition problem into a medical intervention one. Many development workers are dismayed by passive attitudes about maintaining good health. Some feel the proliferation of pills and capsules discourage people from making changes in diet and lifestyle that would give them better control over their health. The widespread use of capsules may also increase a feeling of dependency on outside technologies among the health workers in developing countries. It is difficult to administer a program of high potency vitamin A capsules without some trained health workers in the area, as excessive doses are toxic.

**Fortification of Common Foods with Vitamin A:** This seems to be working quite well in a few locations. Sugar has been fortified with vitamin A in parts of Guatemala with some success. Salt, flour, milk and a few other foods have been suggested as vehicles for vitamin A fortification. This may be promising where large numbers of people eat predictable amounts of certain foods that can be processed under controlled conditions in a central plant. Where fortification doesn't usually work well is in rural areas where most of the foods are locally grown and prepared. These are, not coincidentally, areas where malnutrition is prevalent.
**Local Production of Leaf Concentrate:** Leaf concentrate is something of a midpoint between the simple growing and eating more greens and the more complex, more centralized approaches of capsules or fortification. It seems well suited to small co-ops, school programs, or small business. It takes some effort and capital initiating LC programs, but it is a food that has other values (like iron and protein) in the diet of malnourished children. Some of the leaf concentrate foods like lemonade syrup and dried pasta store well and are very convenient. They are basically ways of preparing dark green leafy vegetables that children will accept well.

"Why do you use sugar in LC drink mixes? Isn't sugar bad for you?"

On several occasions people have objected to our use of LC drinks sweetened with white sugar in child nutrition programs. To convey some idea of how complicated these issues are and how we go about sorting them out, I've outlined the arguments that came up for and against using sugar in these programs.

Arguments against use of sugar fall into three basic categories: 1. Tooth decay  2. Empty calories 3. Other. Tooth decay is dramatically less with drinks than candy etc., as it is dilute and doesn't stay in the mouth long or cling to tooth enamel. The empty calorie argument is greatly offset when used with LC, which is low in calories and high in most nutrients. Other arguments include several related to blood sugar equilibrium problems, including Feingold and other's theory of sugar intake as a cause of hyperactivity in children. This has been largely refuted by a number of well-controlled double blind experiments that showed no correlation between sugar and hyperactivity in children. Children are much more able to digest and absorb large amounts of sugar than adults. Strong reactions to high sugar intake such as hypoglycemia are very rare, and probably the large majority of such reactions are psychosomatic in nature.

Some preliminary studies warn of problems from glucosinated proteins (glucose molecules attaching themselves in a rather unpredictable way to certain protein molecules) with possible negative impact on eyes and kidneys and nervous system. Diabetes may be linked to this response. This is still very sketchy stuff and probably linked to long-term high sugar diets. There are some indications of slight addictivity from high intakes of refined sugars. Some biochemists and nutritionists feel that high intake of refined sugar could aggravate diarrhea because it is such a readily available energy source for bacterial growth. Complex carbohydrates break down more gradually and may be less likely to stimulate bacterial outbreaks.

Honey and brown sugar would behave so similarly in the body that its unlikely to be worth much trouble or money to switch. The LC is rich in the trace minerals that they would supply in small quantities. A number of other benefits have been claimed for honey, over the years, but usually price eliminates it from consideration for use in nutrition intervention programs.
Arguments for using sugar also fall into 3 categories: 1. cheap source of calories. 2. improves palatability and acceptance. 3. helps preserve foods. Many nutritionists would argue that in a marginally nourished population like low income Nicaraguan children, increasing caloric intake is the first priority and that sweet drinks are a reasonable and inexpensive way to do this in sugar producing regions. Drinks typically have less substitution effect than solid foods. That is, two glasses of a sweet drink may add more calories to a child's diet than an equivalent number of calories from a solid source because the mothers more often reduce other food given the child if he receives a solid supplement. The benefit of making a marginally attractive food like LC acceptable to children shouldn't be overlooked. If they will drink two glasses with some extra sugar and one without it, the benefit of the addition LC and lemon juice will almost certainly outweigh the negatives of the added sugar. Increasingly, sub-optimal hydration is seen as a health problem in many 3rd world populations, where high temperature and low availability of good water are found. This can cause kidney problems, electrolyte imbalances, constipation, and other difficulties. This is another benefit of the drink. It is not clear at what point the sugar content would offset the value of just the additional water.

The high osmotic pressure of sugar sucks moisture through bacterial cell walls and makes a cheap preservative that is also a source of calories. Usually liquids greater than 67% sugar are relatively stable. 1.8 kg sugar mixed well with 1 kg 60% LC should be quite stable. A rule of thumb is to emphasize complex carbohydrates as energy sources and try to keep the percentage total calories in the diet from refined sugars to around 5%. This can be extremely difficult in tropical sugar exporting countries.

"What are antioxidants and why are they so important?"

In what is becoming one of the biggest nutrition stories of the century, scientists are finding that many diseases may be closely tied to the cumulative cellular damage done by free radicals. Equally important, they are finding that several compounds called antioxidants exist in common foods that can block these destructive oxygen reactions. Free radicals are unstable molecules that can be created by normal metabolic processes, or from environmental factors like cigarette smoke, ultraviolet radiation in sunlight, and a range of chemicals that people are routinely exposed to. An increasing number of researchers feel that dietary antioxidants are the realistic way to interrupt this cellular deterioration that appears to be linked to many types of cancer, heart disease, Parkinson's disease, cataracts, and dozens of other health problems. Much of this research is still in preliminary stages but, the evidence is rapidly piling up that increased dietary intake of antioxidants is a sound strategy for better long-term health.

There are many different compounds. Three of the most important antioxidants in the human diet are beta-carotene, vitamin C and vitamin E. Leaf concentrate is the richest known source of beta-carotene and a very good source of vitamin E. It contains almost no vitamin C. Some of the other known antioxidants and important food sources of them are given below:
Quercetin - yellow and red onions, red grapes, broccoli, and yellow squash
Ellagic acid - strawberries, blackberries, blueberries, cranberries, grapes, apples,
Brazil nuts and cashews
Glutathion - broccoli, parsley, and spinach
Lycopene - strawberries and tomatoes
Oleic acid - olive oil
Selenium - brazil nuts, seafood, sunflower seeds, and beef liver
Phytates - grains and legumes

"Should milk be used in feeding programs?"

In several famine situations where donated milk made up a major part of the diet, many people suffered from serious intestinal gas and diarrhea. This was due to a widespread genetic inability to digest the sugar lactose, which is found in milk. The undigested milk sugar ferments in the intestine causing gas formation, bloating and sometimes diarrhea. Because of these problems one sometimes encounters a very negative attitude about the use of milk in feeding programs. There has been some dumping of powdered milk into developing countries to maintain high milk prices for farmers in the both the US and Europe. Before 1972 there was tremendous nutritional emphasis on protein and the main milk protein, casein, is considered a benchmark against which to judge protein quality. It was a common belief that milk was an ideal food, partly due to the American Dairy Association's extremely successful lobbying efforts.

Until about 1965 USAID (United States Agency for International Development) was unaware of the extent of genetic lactose intolerance in various populations and there have been accusations of cultural chauvinism because of this. Only among people of northern European ancestry and a few African tribes with long histories of cattle herding, do the majority of the adults tolerate milk sugar well. The percentage of the adults who are intolerant varies greatly from culture to culture, with almost 100% of some groups, like the Thai, intolerant. In other groups, like US blacks, only about 65% are intolerant.

Children up to six years of age are generally able to digest lactose. Even lactose intolerant adults can usually utilize small amounts of milk (up to about ½ liter per day) without discomfort. Lactose intolerant people produce some lactase, the enzyme responsible for breaking down milk sugar, but this tends to decline rapidly with age. If you are working with programs involving adults you should find out what the levels of lactose intolerance are before introducing large quantities of milk. Allergy to milk is usually related to the protein and is much more rare than lactose intolerance, though the two are often confused in Latin America and other places.
"Isn't the normal diet people eat closely tied to their culture? Will they accept new foods like LC?"

It is very difficult to introduce unfamiliar foods, like leaf concentrate, into people's diet. This is especially true in traditional cultures. It is not impossible, however, and it gets easier every year. One needs only to look at the phenomenal popularity of Coca-cola and Pepsi-cola worldwide to recognize that new foods are being adopted by traditional cultures. Powerful multinational corporations heavily promote these foods and their popularity is a testament to the effectiveness of advertising.

Sometimes the changes in diet are economic in nature. In Nicaragua rice has been the primary grain for many years. However, as the economy continues to declines there, people are eating far greater quantities of corn because it is cheaper, and they can no longer afford the preferred rice. At the same time refugees returning to Nicaragua from the United States have brought with them a taste for many of the convenience foods that are popular in the US. Pizza, in particular, has experienced great popularity and dozens of pizza shops have sprung up to supply this demand for a new food.

People all over the world are in the process of making dietary changes that are powered by the increasingly rapid movement of people and information among different cultures. Many times this appears to be exploitative and one sided, as when one watches barefoot malnourished children buying soft drinks from foreign companies. Other times it has a more progressive side. Mexican people are eating less lard than they did ten years ago because they have been educated about the links between high animal fat consumption and heart disease and cancer. Even in small villages this information is arriving and people are taking action.

Ultimately whether leaf concentrate is accepted in a given society will have to do with three things:

1. **Promotion** - can leaf concentrate foods be packaged and sold in a way that attracts food buyers?
2. **Economics** - can leaf concentrate be made and sold at a low enough price to be an affordable alternative to other available foods?
3. **Education** - can people be adequately educated in the value of good nutrition in their lives to make changes in diet based on that information?

"Aren't there other alternative high nutrition foods, like soybeans, that would be easier to introduce than leaf concentrate?"

Mention must be given in this manual to the combination of leaf concentrate and soybeans. While soybeans are an ancient crop in much of Asia, in many developing countries they are being promoted as a new low cost diet improver for malnourished people. Leaf For Life is working with groups trying to introduce soybeans in both
Mexico and Nicaragua. The biggest advantage of soybeans is that they can often be purchased in bulk and stored for use when needed, whereas leaf concentrate requires fresh cut leaves every day. Soybeans are often a cheaper source of protein than leaf concentrate, but LC is usually a cheaper source of iron. Leaf concentrate is the best-known source of beta-carotene while soy has almost none. Together they are quite a nutritional package, and there is no reason why people should have to choose one over the other.

Both leaf concentrate and soybeans can make very efficient use of land resources. The chart below compares protein yield of leaf concentrate from alfalfa and soybeans to some other foods.

<table>
<thead>
<tr>
<th>FOOD</th>
<th>Kgs Edible PROTEIN per Hectare in 6 Month Growing Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Concentrate</td>
<td>1070 kg</td>
</tr>
<tr>
<td>from Alfalfa</td>
<td></td>
</tr>
<tr>
<td>Soybeans</td>
<td>660</td>
</tr>
<tr>
<td>Wheat</td>
<td>475</td>
</tr>
<tr>
<td>Milk</td>
<td>430</td>
</tr>
<tr>
<td>Eggs</td>
<td>140</td>
</tr>
<tr>
<td>Pork</td>
<td>100</td>
</tr>
</tbody>
</table>
Soybeans have nearly twice the protein and much more oil than ordinary beans. One of the things we like best about soybeans is that a very good milk substitute, called soymilk, can be made in a lot of places where children can't afford, or can't digest cows' milk. We have found an extraordinary nutritional package can be delivered in a single portion by mixing together a glass of soymilk with a tablespoon of leaf concentrate and sugar to taste. One glass of this drink can supply a 4-6 year old child with more than 100% of the vitamin A, 83% of the iron, and 37% of the protein suggested by the US Recommended Dietary Allowances.

Cowpeas, alfalfa and soybeans are all legumes that can convert nitrogen in the air to a form that plants can use. This eliminates the need for expensive nitrogen fertilizer. Besides being a big expense for the farmer, nitrogen fertilizer is also very hard on the environment because it uses tremendous amounts of electric energy to produce and it often is responsible for the pollution of ground water with nitrates in agricultural areas.

One of the reasons that leaf concentrate and soybeans make such a good combination is that much of the equipment we use, especially the 5-gallon blender and press tables, works equally for making soymilk. This keeps the equipment costs for both nutritional products very low. Dried soybeans have an advantage over leaf crops in that they store quite well. In areas where leaf crops are not abundantly available all year, we find that soybeans can be used to bridge the gap. Because the processes of making soymilk or soy cheese (tofu) are so similar to that of making leaf concentrate, it is easy to train health workers to make both products in the same workshop. Then, instead of shutting down when leaf crop is in short supply, the program can switch to soymilk or tofu and the children can continue receiving a nutritious boost to their diet.

"Isn't hunger caused by political inequality? If it is how can a technical approach, like leaf concentrate, help?"

Many influential writers on the subject of world hunger feel that the problem will never be resolved until people recognize that it is primarily a political problem. Susan George delineates this view when she describes “... hunger as a function of poverty and poverty as a function of fundamentally inequitable power structures both within and between nations.” From this point of view measures taken to increase food supply such as irrigation schemes, integrated pest management, and post-harvest food processing, are irrelevant to assuring enough that everyone has enough to eat. This outlook has lost some of its appeal as the socialist governments of the world have come undone, and the prospects for revolutionary redefinition of power structures in favor of the poor have greatly diminished.

The criticism of technical approaches to the issue of hunger frequently relates to failures of the "Green Revolution". This is seen as the imposition of technical innovations, mainly in the form of high yielding seed varieties that did dramatically increase food supply but did little to reduce the number of hungry people. The new seeds changed land tenure
patterns and levels of bean consumption at the same time that they increased the supply of rice and wheat. There are always unintended effects, both bad and good, from new technologies.

Technical changes don't take place in a vacuum and both the scale of operations and the choice of operators have implications for the power relationships in the communities affected. The introduction of leaf concentrate technology can be done on an industrial commercial scale, on a domestic scale, or on a cooperative village scale. Leaf for Life tries to gear its projects so that women, who are generally disempowered within current social structures in developing countries, can control them. We normally advocate small, decentralized production units that can remain under local control.

In the long run it will be very difficult to eliminate hunger without fundamentally addressing the inequities of power. It will be equally difficult to eliminate poverty without the introduction of improved food production and processing techniques. The challenge is to develop technologies that don't reinforce the current power structure and to use them as soon as possible to make sure children alive today won't have to wait for big political changes to get enough to eat.
# SECTION VI

## GENERAL INFORMATION

### TROUBLE SHOOTING

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>POSSIBLE CAUSES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>leaf concentrate has strong or bitter flavor</strong></td>
<td>- old leaves were used</td>
</tr>
<tr>
<td></td>
<td>- inappropriate species</td>
</tr>
<tr>
<td></td>
<td>- old leaf concentrate</td>
</tr>
<tr>
<td></td>
<td>(over 2 days refrigeration or 5 days with)</td>
</tr>
<tr>
<td></td>
<td>- delay in processing after leaf harvest</td>
</tr>
<tr>
<td></td>
<td>some fermentation</td>
</tr>
<tr>
<td></td>
<td>(no more than 4 delay advisable)</td>
</tr>
<tr>
<td></td>
<td>- residual liquid or 'whey'</td>
</tr>
<tr>
<td></td>
<td>not well enough pressed out</td>
</tr>
<tr>
<td></td>
<td>- curd burnt during heating of juice</td>
</tr>
<tr>
<td><strong>leaf concentrate is too moist or wet</strong></td>
<td>- curd not pressed firmly enough</td>
</tr>
<tr>
<td></td>
<td>- curd not pressed gradually enough</td>
</tr>
<tr>
<td></td>
<td>- filter cloth is too fine</td>
</tr>
<tr>
<td></td>
<td>- juice stirred too much during heating</td>
</tr>
<tr>
<td><strong>curds</strong></td>
<td>- juice heated too slowly, making very small that clog the filter cloth</td>
</tr>
</tbody>
</table>
leaf concentrate has a gritty texture
grinding
- leaves not washed well enough before and contain dirt and dust
- some species, like spinach have crystalline acid that gives the curd a gritty texture.

leaf concentrate has a fibrous texture
- juice was not filtered before heating

low yield of leaf concentrate (less than 5% of leaf weight)
- old leaves
- very young leaves
- very high water content in leaves or they from rain or from washing
- leaves not ground up well
- juice not pressed well enough from fiber
- juice not heated high enough to coagulate curd

all the processing is going too slowly
washing needed.
- too much time is being spent sorting and leaves. Extreme care is not
- leaves are being hand stripped from stalks
- workers are waiting for one step to be before beginning the next (Usually it is good to grinding while another
- workshop is not arranged efficiently
- tables are too high or too low for working
- socializing among workers or friends and has become too distracting
- children are interfering with work in the workshop

**leaf juice is taking too long to heat**

- pressure is too low on gas stove
- flame is too far below pot

- flame only in contact with part of pot
- breeze on flame and pot
- if wood fire is used; wood is wet or not well enough split up. It may need more air supplied by a small fan
- Cook pot is too deep
- metal of pot is too thick
- no top on pot

**leaf juice burns on pot bottom**

- juice left on heat after it reaches boiling point
- flame not evenly spread over bottom of pot
- pot not cleaned well enough after a previous burn
- lack of gentle stirring during heating

**grinder or macerator motor not running**
- not fully plugged in
- outlet linked to light switch that is not turned on
- circuit breakers off or fuse burnt out
- reset button on motor needs to be pushed
- damaged or wrong size seal has allowed water to pass from blender to motor

**grinder or blender running too slowly**
- motor wired for 220 volts on 110 line
- motor wire for 60 Hertz running on 50 Hz
- too many leaves in blender
- too little water
- leaves not cut into short enough pieces

**meat grinder not grinding leaves well**
- leaves not cut in short enough pieces
- leaves are too wet; juice is filling grinder chamber
- motor shaft and grinder shaft are not properly aligned or connected
- blade is not in place or is in backwards
- holes in die plate are too small or too few
- motor speed is not reduced enough or is reduced too much; should be between 60-90 RPM

children are not showing improvements in health after 4 months on leaf concentrate program

- not enough leaf concentrate is being given per day

- leaf concentrate meals are too irregular

- children are not eating all the meal that is offered

- leaf concentrate food is being shared with other family members

- child is not malnourished

- child is not receiving the usual amount of food at home.

- intestinal parasites or other chronic health
SAFETY

Machinery
- Children should be kept away from machines in use.
- Machines should be unplugged when not in use, when being cleaned, or when being repaired.
- Electric cords should be kept out of water and out of foot traffic.
- Switches should be within easy reach of machine operators.
- Motors should be equipped with manual reset buttons to prevent accidental restarting after they shut off from an overload.
- Guards should always be used to keep hands out of moving machinery. Wooden push rods should be used to feed leaves into the blender or grinder.
- Ear protection should be worn if the noise level from the machines is very high.

Cooking with Gas
- Gas cylinders should be tied or chained in an upright position.
- Make sure all connections are tight and there are no leaks. Use Teflon tape if available. Test connections with a little soapy water. This will let you know if there is a leak.
- If possible, have the gas tank outside, with only the tube or hose inside.
- Don't use a gas cooker in a small unventilated room.
- Make sure gas is turned completely off before leaving workshop.
- Any flame should be at least 2 meters away from the gas tank. Further is better.
- Keep tubes, hoses and connections as out of the work area if possible to avoid people tripping on them.

General Safety
- Use normal precautions when dealing with large pots of hot liquids.
- Get help if you need to move something heavy. Lift with your legs not your back. Don't risk hurting your back.
- Keep floors free from wet areas if possible, especially around machinery.
- Wear footwear with good footing rather than going barefoot or wearing loose sandals.

HYGIENE

- All workers should wash their hands well before handling food.
- Animals should be kept out of the work area.
- Workers who are coughing or sneezing should not handle food.
- Equipment should be well cleaned after each use. Pulped leaves, leaf juice, and leaf concentrate can all ferment quickly if left on machinery.
Diseases Transmitted by Food

Diarrhea is the largest cause of death in children. Worldwide an estimated four million children under the age of five die each year from diarrhea. The symptoms of food-transmitted disease are usually diarrhea and sometimes nausea and cramps following the consumption of food or water that is contaminated. There are two types of food borne diseases. Intoxication is when toxins produced by microorganisms living in food before it is eaten poison a person. Infection is caused when living microorganism in food multiply after they reach the person's digestive tract. Young children and people with lowered immune system resistance are those most likely to die from food borne disease.

The types of bacteria responsible for intoxication diarrhea are not normally present in leaf concentrate processing and should not be a problem in LC programs. Many of the worst agents of infection are thrive mainly on meat, poultry and seafood. Some of the bacteria that can cause infections in the human digestive system are present in the soil and throughout the tropical environment. These include shigella, listeria, E. coli, Staphylococcus aureus, and Bacillus cereus. Fortunately all of these are killed by heating to boiling as is done with the coagulation of leaf juice. The main danger of bacterial infection from leaf concentrate comes from it being recontaminated after it is pasteurized.

To avoid this it is important to store the leaf concentrate in very clean containers and either refrigerate it or dry it as soon as possible after it is pressed. If it is to be stored for more than a day or so without refrigeration it should be resuspended in an acidic wash water to lower the pH below 4.5. This should be done with a diluted acid, if it is necessary. Moist leaf concentrate should be eaten within a week even if it is refrigerated.
LEAF CONCENTRATE:  
SOME BASIC RELATIONSHIPS

**LAND AREA**  
1 hectare = 100 meters (327 feet) on a side or c. 107,000 square feet or c. 21/2 acres .  
1 acre = c. 64 meters (c210 feet) on a side or c. 43,000 square feet or .4 of one hectare  
(Nicaragua) 1 Manzana = c. 80 meters (265 feet) on a side or c. 70,000 square feet or .7 hectare or 1.6 acres.

**WATER REQUIREMENTS**  
Rapidly growing green crops usually need between 3-4cm (1-1 1/2 inches) of water per week for top growth, depending on soil, air temperature, and humidity.  
or 60-90 gallons per 100 square feet or 65,000 - 97,000 gallons per hectare per week or 26,000 - 39,000 gallons per acre per week.

**GREEN CROP YIELD**  
Highly variable.  Probably 3-5 kg per square meter ( 2/3 - 1 lb per square foot) per year is a reasonable estimate for our use. 35-50,000 kg per hectare;  
or 30-45,000 lbs per acre (1kg = 2.2 lb).  This comes out to about 100 kg a day per hectare or about 100 lbs a day per acre.  Triple these yields are sometimes achieved under intensive conditions.

**TYPICAL YIELD OF LEAF FRACTIONS**  
100 kgs leaf crop, ie. alfalfa or cowpeas (18-20 kg dry matter)  
4-7 kg LC at 60% moisture (1.5 -2.5 kg dry matter)  
45 kg fiber at 70 % moisture (c. 13.5 kg dry matter)

**COMPOSITION OF LEAF CONCENTRATE**  
100 gr. of 60% moisture LC should contain approximately:

- **24 gr**  
  *Protein*  (High quality protein equivalent to meat or fish, lower than milk or eggs, better than grains, or beans).

- **50,000 IU**  
  *Vitamin A*  (As beta-carotene)

- **40 mg**  
  *Iron*  (This is an average of 20 samples worldwide. Actual amount will vary greatly with soil and processing equipment).

- **720 mg**  
  *Calcium*

- **140**  
  *Calories*

- **140 mcg**  
  *Folic Acid*
USRDA for 4-6 year old children:
Protein         30 g
Vitamin A    2500 IU
Iron            10 mg
Calcium        800 mg
Calories      1800
Folic Acid       200 mcg

- see section on nutrition -

MISCELANEOUS RELATIONSHIPS
1 kg fresh leaves should yield 1/2 liter or 1 pint juice.

1 tablespoon fresh LC = c. 15 gr. or 1/2 oz.

1 kg LC will provide 66 portions of 15 gr. each

1 pound LC will provide 30  15 gr. portions.

For daily portion of 15 gr., figure c. 30 square meters (300 square feet) of good land per child.

1 pound LC will provide 18    25 gr. portions.
1 kg LC will provide 40 portions of 25 gr. each.

To provide a daily portion of 25 gr., figure 50 square meters (650 square feet) of good land per child.

On Dry Weight Basis: LC should be 50-65% protein, 20-25% lipids, 5-9% ash, .8-1.0% beta-carotene with significant amounts of calcium, xanthophyll, iron and vitamin E.

FEED VALUE OF FIBER When figured on a dry weight basis, the fiber left over from leaf concentrate processing has approximately the same feeding value to animals as unprocessed fresh leaf crop. Because fresh alfalfa and other leaf crops are usually around 20 % dry matter, while the residual fiber is around 30% dry matter; the fiber has about 1½ times the feeding value, per kilogram, as the leaves that it was made from.

The fiber remaining from processing one ton of alfalfa should provide the bulk of the forage requirement for 25-30 cows who can produce about 75 -100 liters of milk daily.If we assume a daily ration of 2 kg dry matter for every 100 kg cow weight, this 45 kg of fiber will feed two and a half 300 kg cows. The 100 kg of unprocessed leaf crop would feed three and a third cows of the same weight.
WHEY Whey is rich in nitrogen and potassium but deficient in phosphorus as a fertilizer. It is not acceptable in human diet because of concentrations of nitrates, oxalic acid, and other anti-nutrients. It has been remixed with the fiber for cows with good results, though watering pigs with whey has led to kidney problems over time. 10 liters whey will cover 1 meter sq. 1 cm deep. 2-3 cm per week may be needed to supply optimum water. This amount may damage seedlings and some plants. Diluted whey, as in that from blender processed leaf concentrate, is safe for plants. It is best used for high value crops near processing site.

- see section on by-products -

**YIELDS OF LEAF CONCENTRATE VS CROP MOISTURE**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield of fresh leaf concentrate (60% moisture) (grams fresh LC per 100 grams of crop)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Content (%)</td>
<td>15% DM yield</td>
</tr>
<tr>
<td>75</td>
<td>9.38</td>
</tr>
<tr>
<td>80</td>
<td>7.5</td>
</tr>
<tr>
<td>85</td>
<td>5.63</td>
</tr>
<tr>
<td>90</td>
<td>3.75</td>
</tr>
</tbody>
</table>
RELATIONSHIPS BETWEEN
YIELDS OF LEAF CONCENTRATE AND FIBER
AND CROP MOISTURE CONTENT

Grams of dry LC per 100 grams of crop dry matter

<table>
<thead>
<tr>
<th>Yield Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than 15 grams</td>
<td>Excellent Yield</td>
</tr>
<tr>
<td>12.5 to 15 grams</td>
<td>Very Good Yield</td>
</tr>
<tr>
<td>10.0 to 12.5 grams</td>
<td>Good Yield</td>
</tr>
<tr>
<td>7.5 to 10.0 grams</td>
<td>Fair Yield</td>
</tr>
<tr>
<td>Less than 7.5 grams</td>
<td>Poor to Very Poor Yield</td>
</tr>
</tbody>
</table>

Kg of product per 100 kg of crop with a leaf concentrate yield (dry matter to dry matter) of:

<table>
<thead>
<tr>
<th>Moisture Content of Crop</th>
<th>Product</th>
<th>7.5%</th>
<th>10.0%</th>
<th>12.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>80%</td>
<td>leaf concentrate</td>
<td>5</td>
<td>6.7</td>
<td>8.3</td>
</tr>
<tr>
<td></td>
<td>fiber</td>
<td>55</td>
<td>51.7</td>
<td>49</td>
</tr>
<tr>
<td>85%</td>
<td>leaf concentrate</td>
<td>3.8</td>
<td>5</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>fiber</td>
<td>41.3</td>
<td>39</td>
<td>36.7</td>
</tr>
<tr>
<td>90%</td>
<td>leaf concentrate</td>
<td>2.5</td>
<td>3.3</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>fiber</td>
<td>27.5</td>
<td>26</td>
<td>24.5</td>
</tr>
</tbody>
</table>

Note: Both leaf concentrate and fiber assumed to be at 70% moisture. Leaf concentrate should be pressed to 60 % moisture whenever possible.

Walter Bray February 1993
SOME RULES OF THUMB

1. If it smells bad, it is bad. This applies to leaves, LC, and products made from LC.

2. If you can recognize pieces of leaf in the pulped leaves, they probably aren't ground up enough.

3. If you take a pinch of fresh green leaf and rub it vigorously between your thumb and forefinger it should produce a thin green watery juice. If there is no juice or the juice is sticky, it is not a good choice for making LC.

4. If you can squeeze juice from the fiber with your bare hand after it has been pressed it is probably over 70% moisture and not well enough pressed.

5. If you take a pinch of fresh LC and smear it with your thumb across your palm, it should roll back up and leave your palm clean. If it goes on like finger paint and leaves your palm green it is too wet; probably 70% moisture or more.

6. If you are getting a 10% yield you are probably doing something wrong. If 100 kg of fresh leaves is producing more than 7 kg of leaf concentrate, chances are it is very wet LC. Normally 5% is typical, don't feel bad if you are getting 5% and reading about others getting 10%; reality is on your side. The same is true with dry yields over about 2.5%.

7. Nothing changes the economics of LC as greatly as wet curd. Assume you are yielding 2% on a dry basis, and you are processing 200 kg of leaves and selling fresh LC for $4 per kg. If your curd is well pressed (60% moisture) you will get $40 worth of LC. If your curd is poorly pressed (75% moisture) you will have $64 worth of curd. Of course, the difference is that you are selling 6 liters of water for $24. This is a tremendous temptation, but a death threat to LC projects. It is why we increasingly recommend using dried LC.

8. Averages are humbling things. If you normally produce 4 kg of dry LC per day of work, but on average you don't process one day a week because of electric problems, average production is 3.2 kg not 4. If the shop is closed for Holy week, two weeks at Christmas, whenever there is a storm, whenever a worker has a sick relative, and whenever you are out of leaves or a machine needs repair, the average daily production over the year may be only 2 kg.

9. Wholesale prices are lower than retail. If you see noodles for sale in a health food shop for $2.00 per kg, this does not mean that the producer of the noodles receives $2.00. More likely he gets $1.00 and the storeowner and other middlemen get the other one.

10. There is always some waste. If you are making syrup you will end up with half a bottle left over. If you make churritos some will burn or break. If they are well made some will get eaten in the shop before being packaged.
COMMUNICATIONS

An important part of any leaf concentrate project is communications. A few suggestions on communications from my experience with leaf concentrate projects.

Learn the local language.
Every field worker I've talked to that has worked in Latin America wishes that he had spent more time learning Spanish before going there to work. The same is likely true of other languages. Every bit helps; whether it’s high school courses, language tapes, a short intensive course in a foreign country, or just studying a phrase book. Keep studying after you’ve arrived in a foreign country. Use the language even if you don't speak gracefully. Avoid hanging out exclusively with ex-patriates who speak your language. That will slow the learning process down.

Use terms that are as universal as possible.
Your reports from the field are of great interest to a range of people working with leaf concentrate in countries all over the world. Using scientific as well as local names for crops, weeds, insects, foods etc. that are not commonly known worldwide will increase the value of your information. I'm frequently frustrated by reports on crops or recipes from India that use local names unknown to me. Sometimes I can look them up, because I have access to good libraries, but this is a time consuming and often fruitless labor. Other workers in developing countries are less likely to be able to look up these names and thus these reports are often worthless as a result. Usually someone at a local agricultural school will know the scientific names of plants and pests important in that region.

The same holds true with the use of local currencies and measuring systems. People don't have any idea how big a field of 10 Indian bighas or 6 Nicaraguan manzanas is outside of those cultures. Detailed economic analysis in local currency without reference to an exchange rate to one of the larger currency systems like the US $ or British £ can also be worthless. In general we should include metric system measurements as well as local ones in any reporting.

Use standard field tests whenever possible.
For example, the percentage of dry matter in leaves compared to the percentage of leaf concentrate dry matter from those leaves, provides a lot of good information about a crop and how likely it is to be a useful plant for making LC. Tests that use fresh weight without giving the percentage of moisture in either the leaves or the LC provide far less information.

Work toward high-speed low cost computer links.
Electronic information networks, like Eco-Net, and PeaceNet, are opening up possibilities to exchange information quickly and inexpensively worldwide. We need to move towards these types of systems as telephone calls are very expensive and the voice...
quality often bad, and mail is too slow between projects and office. Frequently there is a
month or more lag between correspondence and questions asked don't get answered. If
we could develop a somewhat standardized format one could respond by saying
something like "please clarify point 3 in report

# 256". The linking of the actual field situation with the experience and resources of the
home offices is frequently quite weak.

Use a standardized monthly production report for each project.
Monthly reports on production provide very valuable information and help us identify
problem areas quickly. A sample monthly report form that can be copied is in the
appendix of this manual.
CONSIDERATIONS IN SETTING UP PROJECTS

The following list of questions may seem very long. It is not necessary to answer them all in order to be able to run a leaf concentrate project, but they give a good idea of the many factors that can affect the success or failure of such project. Generally, the more thought that goes into these types of questions before a project is set up, the greater the likelihood of success.

Agricultural
- Are there any commercial crops currently grown in the area that could be used for LC production?
- Rainfall information. How much? What months?
- Is sufficient land available to grow leaf crops? Not too steep or very rocky?
- Are tractors available to work the land? Crops like cowpeas that are frequently replanted need easy access to tractors or animals or roto-tillers to prepare soil. Beware too easy yes answers.
- How hot is it in the hottest season? When and for how long?
- What are the main crops now grown in that area?
- Any information on yields of corn, sorghum, alfalfa etc is helpful for estimating land requirements for other LC crops. Get more than 1 opinion.
- Any information on land prices per hectare of farmland? Irrigated farmland?
- Rental or lease agreements used for land tenure?
- Market prices and seasonal availability of forages and animal feeds, especially dairy feed.

Nutritional
- Evidence of malnutrition in children. Any available weight for age, weight for height or height for age data.
- Night blindness in children?
- Anemia in children under 5 and pregnant women?
- General impressions of frequency and severity of diarrhea, respiratory infections and measles?
- Seasonal fluctuations in these?
- Do other feeding programs exist in the area? Are other agencies and organizations active?

Dietary
- What percentage of the children is breastfed? To what age on average?
- Are any greens eaten regularly by children?
- Carrots?
- Orange fruits or vegetables?
- Impressions of consumption of meat, fish, eggs and milk?
- Is milk vitamin A fortified?
- Prevalence of home gardens?
- What is grown?
- Availability of greens in local stores?
- What do women perceive as shortcomings in their diet? i.e. "If you had $10 more a week to spend what foods would you buy more of?"
- Snack food patterns?
- Are there any important food taboos, especially for children’s food?

Economic
- Wages or income of agricultural workers?
- Seasonal fluctuations in family income?
- Income generating activities for women? i.e. assembly plants,? home crafts?, field work?
- What can they earn in 4 hours? This plays a big role in how women will evaluate economic potential of LC project.
- Price per kg of staple foods at local stores.
- What cook fuel is used? Cost per month per household?
- Estimated cost of food as percentage of income?
- Is there an apparent market for LC or must one be developed?
- Is there an apparent market for the fiber or must one be developed?

Building for Leaf Concentrate Workshop
- How far is building from the fields of leaves?
- Over what type of roads or path?
- Will leaves be hauled by wheelbarrow, bicycle? horse cart? truck?
- How big is the building or room?
- Who owns it?
- What competing uses are there for the building?
- Can equipment be secured against theft or vandalism?
- How easy is it to clean?
- What is the electric capacity in the building?
- Is running water available? Drinking quality?
- Is building screened to keep out insects?
- Can processing and feeding be done in same building?
- Is there a good drainage system? A sanitary toilet

Machinery
- Are there qualified people involved in the project who can do basic machinery work?
- Welding?
- Carpentry?
- Installing gas cooking equipment?
- Can a college level technical or agricultural school be integrated into program?

Use of By-products
- Are there goats, rabbits, sheep, or cows that can be integrated into the project within wheelbarrow distance of processing center?
- Are there crop fields near enough the workshop to haul whey in buckets for fertilizer?
- Are there any bio-gas programs nearby?
- Are mushrooms commonly eaten in the area?
- What is the cost and availability of off-season cattle feed? Hay?
- Cost per hectare of urea or other nitrogen fertilizer for corn, or sorghum, or other basic grains?

Organizational
- Brief history of partner organization and its leading characters.
- How will LC be distributed?
- Will an existing distribution system be used or a new one created?
- Is motivation primarily nutrition intervention, income generation, or some other factor?
- Will leaf concentrate be sold or given away?
- If sold who will get the money?
- How many children will receive leaf concentrate?
- Will the children come to a central feeding center or will the leaf concentrate be delivered to the homes of the children?
- Are there records available of children’s names, ages, height and weight?
- Will pregnant and nursing mothers receive leaf concentrate?
- How are mothers involved?
- Will workers be volunteers on rotation?
- Is there any paid staff?
- Is there a contact person for your group that can be reached by phone?
- Other national or international agencies that co-operate with or finance this organization. Names and addresses of contacts for these with contacts

Financial
- How do people envision financing project?
- Estimation of set up costs?
- Estimation of yearly operating costs?

Transportation
- How long does it take to get to the nearest large town by bus? Cost? Frequency of buses?
- How long does it take to get to the nearest large city?

Miscellaneous
- Are indigenous people involved in the design and management of the project?
- Is the local political leadership enthusiastic about the project?
- Are there any people who are hostile or very suspicious of the project?
- Are there related projects that might feel threatened by a leaf concentrate project?
- Or that might become integrated with one?
- Is the project leadership closely tied to one political party or other group such as a church that may make segments of the local population reluctant to participate?
These recipes are offered simply to give an idea of the many ways in which leaf concentrate can be prepared in different cultures. Recipes are always adjusted to local conditions of taste and availability of ingredients. We would love to hear of any new recipes or variations on these that you think are good. Each of these recipes provides far more essential nutrients to the body than the traditional recipes on which they were based. The addition of leaf concentrate can turn an ordinary food into a nutritional powerhouse.

### Basic Leaf Concentrate Syrup formula

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>375 ml water</td>
<td>12 fluid oz</td>
</tr>
<tr>
<td>1 kg 60% moisture LC</td>
<td>2 lb</td>
</tr>
<tr>
<td>2 kg sugar</td>
<td>4 lb</td>
</tr>
<tr>
<td>30 g salt*</td>
<td>25 g</td>
</tr>
<tr>
<td>1.7 g ascorbic acid**</td>
<td>1.5 g</td>
</tr>
</tbody>
</table>

Mix well in blender. Approximately 15 grams LC per 30 ml (fluid oz).

### Lemonade Concentrate Syrup

- 1 liter lemon juice
- 2 kg (3.3 lbs) sugar
- 1 kg (2.2 lbs) moist leaf concentrate*
- 50 ml lemon extract (if available)

Blend the leaf concentrate at the highest speed in the lemon juice and extract. Gradually add the sugar and continue blending until very smooth. This syrup can be put in a bottle with a tight fitting top and stored for later use. Mix two tablespoons of the syrup in a large glass of water, or a half liter of syrup in 2 gallons of water.

* Dried leaf concentrate does not work well in thin liquids like lemonade. Even with using moist leaf concentrate some of the solids will settle so it is a good idea to stir up the drinks immediately before serving.

### Pasta

- 3 - 4 kg (6 1/2 - 9 lbs) wheat flour
- 1 kg (2.2 lbs) moist leaf concentrate or 400 gr dry
- 2 tablespoons salt

Mix flour and salt, then add leaf concentrate and a small amount of water. Knead for 10 minutes. Dough should be very heavy but elastic. Roll the dough out as thin as possible and cut into strips. These can be cooked as is or dried in a dark room, sealed in a plastic bag and cooked when convenient.
note: Hand operated stainless steel pasta rollers are available in some gourmet cook shops for about $50 US. They make very uniform pasta.

**Soup Nuggets**

- 1 kg (2.2 lbs) wheat flour
- 2 kg (4.4 lbs) moist leaf concentrate or 800 gr dry
- 100 g (3 1/2 ounces) salt
- flavorings to taste

Mix the salt, flour, and flavorings together and then add the leaf concentrate to make a dough. Roll the dough out in a layer about 1/2 cm thick. Cut into small squares. These squares can be dried, then added to rice or soups or stews. They can also be cooked in boiling water for 3-5 minutes before being dried. In that case they will need no further cooking. When they are well dried they will store well if sealed and kept from sunlight.

note: powder, chili, mustard, horseradish, garlic, onion ginger, or other strong spices can be used to make nuggets that will add flavor and nutrition to any cooked dish.

**Atol (Latin America)**

- 1 kg (2.2 lbs) corn (maize) flour
- 1 kg (2.2 lbs) bananas
- 1 kg (2.2 lbs) moist leaf concentrate or 400 gr dry
- 250 grams (1/2 lb) sugar

To a mixture of corn flour and sugar, add water and cook for 10 minutes. Mash bananas and leaf concentrate together and add mixture to the cooked flour. Mix thoroughly. Remove from heat and serve in bowls.

note: Atol can be made as a hot thick drink or as a very thick pudding or pastry filling, or depending on how much water is used. Many people prefer atol made with corn starch as it is smoother in texture.

**Porridge***

- 2 kg (4.4 lbs) ragi flour (millet or sorghum)
- 1 kg (2.2 lbs) rice
- 1/2 kg (1.1 lbs) brown sugar
- 1/2 kg (1.1 lbs) moist leaf concentrate or 200 gr dry

Cook the rice, ragi flour, and sugar for 15 minutes in enough water to make a fairly thick porridge. Thoroughly mix in the leaf concentrate and serve warm.

note: This basic porridge can be made with any locally available grain or with starchy roots like cassava or potatoes.
PORRIDGES AS WEANING FOODS

Both atol and porridges are frequently used as weaning foods for infants. The addition of leaf concentrate to the traditional porridges can make a tremendous difference in the health of infants during this time of extreme nutritional vulnerability.

A very serious problem with porridges as weaning foods is that young children usually don't get enough calories and nutrients from the volume of porridge they will eat. This is because the nutrient density, or amount of essential nutrient per volume of food, is too low. If parents try to increase the nutrient density of the porridge by adding more solids it becomes very thick and gloppy and the children will eat less of it. If the porridge is made thinner with more liquid, children will consume a larger volume but most of the difference is simply water, so the intake of nutrients is about the same. The nutrient density can be improved by adding leaf concentrate, and oil, or sugar.

An alternative strategy involves breaking up the starch bonds that make porridge thick and gloppy. This can be done by adding 5 - 20% flour from sprouted corn or sorghum. These sprouted grains are rich in amylase that breaks the starch bonds and makes the porridge more liquid. By using these sprouted grains much more flour can be added to the porridge that increases the nutrient density up to three times. The amylase is inactivated at temperatures above 70 degrees C. (160 degrees F.) so the sprouted grain flour needs to be added to the porridge after it has cooled a bit.

The grains should be washed then soaked 8-10 hours in clean water. After that they need to be left in a warm dry place and rinsed twice a day for three days. The sprouted grains are then sun dried. When they are very dry the grains should be rubbed between your hands to remove all the root hairs and shoots. *THIS IS VERY IMPORTANT WITH SORGHUM BECAUSE THE VEGETATIVE PORTIONS OF SPROUTED SORGHUM GRAIN CONTAINS TOXIC HYDROCYANIC ACID. DO NOT EAT SPROUTED SORGHUM WITHOUT CAREFULLY REMOVING THE ROOT HAIRS AND SHOOTS.* White sorghum works far better than brown or purple types of sorghum. I recommend using sprouted corn to avoid any danger from sorghum. After the sprouted grains are fully dry they can be ground like any other grain. The amylase activity of the sprouted grain flour gradually diminishes with time, so it should be used within two weeks of when it is sprouted. While this may be extra work, in many areas grain sprouting is already widely practiced at the household or small business level. for various reasons including the brewing of beers.

**Soymilk Shake**
- 250 ml (1 cup) moist leaf concentrate or 100 ml dry
- 2 1/2 liters soymilk (or cows' milk)
- 1 1/4 sugar
- 2 tsp vanilla extract or flavoring.
Blend the leaf concentrate well in 1 liter of soymilk, then blend the sugar well with another liter of soymilk. Mix these two and the remaining soymilk together well in a large enough container. Makes 10 glasses.

**Frozen Snack**

250 ml (1 cup) moist leaf concentrate or 100 ml dry
250 ml (1 cup) sugar
2 bananas
1250 ml (5 cups) soymilk (or cows' milk)

Blend all the ingredients together well. Pour into 10 small plastic bags and tie firmly closed, then freeze. These can be removed from the bags and eaten with a spoon, or they can be sucked through a hole bitten in the corner of the bag.

**Laddu (India)**

1 kg flour
1 kg brown sugar
1 kg moist leaf concentrate or 80 grams dry
200 grams vegetable oil

Dissolve the sugar in a little water; add the flour and oil. Cook for 15 minutes. Mix in the leaf concentrate and let cool to near room temperature. Form the mixture into little balls (about 25 g each). These can be rolled in sugar if desired.

*note: any locally available flour can be used to make the laddu. Flavorings like ginger can be added as can chopped nuts or fruit*

**Tortillas (Mexican and Central American corn flatbread)**

1/2 kg corn flour
100 g wheat flour
100 g moist leaf concentrate or 40 grams dry

Mix all the ingredients and knead for 5 minutes. Form small balls and press flat by hand or with a wooden or metal tortilla press. Grill on both sides until cooked through. Serves 5 adults or 10 children.

**Tamales (Mexico)**

500 ml (2 cups) corn flour (masa harina)
125 ml (1/2 cup) moist leaf concentrate or 50 ml dry
2 teaspoons baking powder
1 teaspoon salt
80 ml (1/3 cup) lard or vegetable shortening
1 1/2 cup soup stock or water
Combine dry ingredients. Beat the lard until creamy, then gradually beat in the dry ingredients. Slowly add the soup stock or water, stirring constantly. Spread about 1 tablespoon of this dough in the center of a clean corn leaf. Wrap the dough in the corn leaf by neatly folding in the edges. Repeat until all the dough is wrapped. This should make around 25 tamales. Steam the tamales for 40 - 60 minutes. Serve hot. About 3 per person.

note: The tamale dough can be flavored with chili or other flavorings, or sweetened. A tablespoon of various types of fillings can also be enclosed by carefully placing it on the center of the dough before it is wrapped.

Uchepos (Mexico)

Uchepos are made the same way as tamales except they use dough made from corn that is not fully ripened or dry. They has a unique flavor and are a traditional dish of Michoacan, Mexico.

Kola Kenda (Sri Lanka)

500 ml (2 cups) dry rice
250 ml (1 cup) grated coconut
250 ml (1 cup) moist leaf concentrate 0 100 ml dry

Cook the rice and coconut until a thick porridge is formed. Mix the leaf concentrate in thoroughly. Serve warm.

note: Kola kenda is a traditional dish of Sri Lanka, where it is normally made with fresh green leaf juice. The version made with leaf concentrate is well accepted there.

Curried Potato Soup

1 1/2 kg potatoes
250 ml (1 cup) moist leaf concentrate or 100 ml dry
3 medium onions
60 ml (1/4 cup) butter, margarine, lard, or oil
2 tsp curry powder
1 tsp salt
1 tsp dill seed

Peel, cut and boil potatoes. Add onion to boiling water for about 5-10 minutes. Strain and add leaf concentrate, butter, and spices. Blend until creamy, adding more water or milk if needed. Serve hot or cold. Different spices may be used for variations.

Lemon Trail Bars

250 ml (1 cup) moist leaf concentrate or 90 ml dry
250 ml (1 cup) sugar
125 ml (1/2 cup) shortening
125 ml (1/2 cup) flour
125 ml (1/2 cup) rolled oats
125 ml (1/2 cup) raisins
1 1/2 tsp lemon extract or grated lemon peel

Mix all the ingredients together well. Spread 1 1/2 cm (1/2 inch) thick layer of mixture on greased cookie sheet. Bake for 40 minutes in slow oven. Slice into bars then let cool. Other flavorings, like almond, can be substituted for lemon.

**Barfi (India)**

<table>
<thead>
<tr>
<th>50 g</th>
<th>LC (fresh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 g</td>
<td>Bengal gram flour</td>
</tr>
<tr>
<td>125 g</td>
<td>oil</td>
</tr>
<tr>
<td>250 g</td>
<td>sugar</td>
</tr>
<tr>
<td>50 g</td>
<td>potato flour</td>
</tr>
<tr>
<td>25 g</td>
<td>milk powder</td>
</tr>
<tr>
<td>5 - 6</td>
<td>cardamoms</td>
</tr>
</tbody>
</table>

Roast Bengal gram flour in half the oil, add milk powder. Sauté potato flour and LC in remaining oil. Mix enough water to sugar to make thin syrup. Add Bengal gram flour and LC mixture to this. Stir constantly while heating. When about to set mix in crushed cardamoms and spread evenly on greased tray. Cut into 20 diamond shaped pieces.

**LC Rice (India)**

<table>
<thead>
<tr>
<th>1 cup</th>
<th>rice</th>
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</thead>
<tbody>
<tr>
<td>1/4 cup</td>
<td>fresh LC</td>
</tr>
<tr>
<td>1</td>
<td>onion</td>
</tr>
<tr>
<td>3 tablespoons</td>
<td>oil</td>
</tr>
<tr>
<td>2-3</td>
<td>green chilies</td>
</tr>
<tr>
<td>1/2 tsp</td>
<td>curry powder</td>
</tr>
<tr>
<td>2</td>
<td>tomatoes</td>
</tr>
<tr>
<td>1/2 tsp</td>
<td>chili powder</td>
</tr>
<tr>
<td>salt to taste</td>
<td></td>
</tr>
</tbody>
</table>

Brown onion and curry powder. Add rice and fry for 10 minutes. Add LC, chilies, chili powder and salt and enough water to cook the rice. When rice is half done add tomatoes. Serve hot.

**Tikki (India)**

<table>
<thead>
<tr>
<th>200 g</th>
<th>potatoes</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 g</td>
<td>LC (fresh)</td>
</tr>
<tr>
<td>50 g</td>
<td>potato flour</td>
</tr>
<tr>
<td>2 Tbsp</td>
<td>sugar</td>
</tr>
<tr>
<td>200 g</td>
<td>Bengal gram flour</td>
</tr>
<tr>
<td>2</td>
<td>onions</td>
</tr>
<tr>
<td>4</td>
<td>green chilies</td>
</tr>
<tr>
<td>150 g</td>
<td>oil</td>
</tr>
<tr>
<td>1 tsp</td>
<td>curry powder</td>
</tr>
</tbody>
</table>
1 tsp  garam masala
salt to taste

Mash potatoes and add LC, potato flour, sugar, garam masala, salt, green chilies, and one chopped onion. Saute remaining onion with half the curry powder. Add LC mixture and cook 5 minutes on low fire. Remove from heat and let cool. Form into 20 balls. Flatten the balls a little and dip them in a light batter made from the Bengal gram flour, the remaining curry powder, salt, and enough water for a light consistency. Fry till crisp. Serves 10 people.

**Tamarind Jelly** (Nicaragua)

1 kg  sugar
250 g  tamarinds
1 liter  water
2 Tbsp  fresh LC
1 tsp.  cloves

Soak tamarinds in water. Remove seeds. Slowly cook sugar in water and tamarind extract. Add Cloves and LC. Heat slowly till thick.

**Green Salsa** (Mexico)

300 g  tomatoes
1/2  onion
4  chili serranos
2 small  chili perones
60 g  LC (fresh)
1 piece  cilantro
1 clove  garlic
salt to taste

Cook the chilies and tomatoes for 10 minutes. Add all the remaining ingredients and mix briefly in a blender or with an egg beater or spoon.

**Churritos** (Latin America)

350 g  corn (maize) flour
125 g  LC (fresh) or 45 g dried
100 g  wheat flour
1/2 tsp  baking powder
salt to taste
enough oil to deep fry

Mix all the ingredients well. Drive through holes in a meat grinder with the knife removed (.5-1 cm holes). Fry the worm like churritos and serve as a snack.
**Potato - Carrot Pancakes** (Mexico)

3/4 kg potatoes
3/4kg carrots
1 cup bread crumbs
2 eggs
1/4 kg grated cheese
3 Tbsps. LC (fresh)

Wash and peel the potatoes and carrots, then grate them into the same bowl. Mix LC, bread crumbs and salt together. Then mix in the cheese and the beaten eggs. Drop on hot frying pan by the tablespoon and cook like a pancake.

**Swedish Meat Balls**

1/2 cup fresh LC (or 1/4 cup dried)
1 cup dry bread crumbs
1 egg
1 onion (chopped)
1 clove garlic (chopped)
1/4 cup peanuts (chopped)
1 tsp. salt
1 tsp chili powder

Mix together all ingredients. Form into balls and fry in hot oil till crisp.

**Leaf Burger**

375 ml (1 1/2 cups) dried bread crumbs
250 ml (1 cup) moist leaf concentrate or 100 ml dry
1 egg
60 ml (1/4 cup) wheat flour
1 tsp mustard
1 clove garlic chopped fine
1 tsp salt

Mix all ingredients well. Form into flat patties about 8 cm in diameter. Fry these on both sides until they begin to brown. Serve on bun with catsup. This mix can be made into meatless `meatballs' as well, by forming balls instead of flat patties.

**Fiona's Vegan Leaf Burgers**

1 cup fresh LC
1 cup rolled oats
1 cup chopped onions
1/2 cup peanuts (soaked)
cumin, chili, and salt to taste

Combine all ingredients. Form into patties and fry.
DEVELOPMENT CRITERIA
FOR LC FOODS

In testing different LC foods we are looking mainly for improvements in economics, acceptance, or nutrition. Although Leaf for Life is ultimately concerned with improving nutritional well being, in my opinion the priorities for testing are in the order given above. As we present the case for greater use of leaf concentrate to funders and policy makers, the most serious doubts raised are generally concerning economics, followed by acceptance. The nutritional value of leaf concentrate is challenged less frequently.

While most changes that affect any one of these factors will affect the other two, useful attributes for LC foods are sorted into these three categories below.

**Economics**
- **Long shelf life.**
  In many areas this means products that can be made during the rainy season and marketed six months later. A variation on this is making foods year round from dried LC.

- **Inexpensive, readily available ingredients.**
  Special attention to foods that tend to be inexpensive where malnutrition is prevalent, ie. cassava, yams, plantains, corn, sorghum, rice and potatoes.

- **Simplicity of process.**
  To be of much use in either fighting malnutrition or income generation for women LC foods must be fairly easy to make using inexpensive equipment that can be reasonably maintained in village conditions. Labor requirements should be well thought out, as should the need for technical expertise or precision.

- **Substitution for expensive foods.**
  It may be easier to market a cheaper substitute for a high demand food like meat or ice cream, than a premium priced enriched staple food like pasta or porridge.

- **Packaging.**
  Packaging can make up a big part of the cost of a food. Liquids and foods that are brittle or sticky, for example, can present costly problems.

**Acceptance**
- **Ready to Eat.**
  Foods that require no cooking are generally easier to introduce. Generally, people are more adventuresome about trying a snack food in the plaza than trying to integrate a new staple food into the traditional diet at home. Snack foods appeal more to the young, are identified with fun, and are usually sold in very small units, all of which encourages people to give them a try. Snacks represent the fastest growing part of the diet in many developing countries. They are usually not very nutritious, especially relative to their cost. Companies from developed countries control much of the snack market. So
displacing a snack food with a new LC one would usually have a clear benefit both nutritionally and economically for the community. Development policies are beginning to question how introductions of foods might damage local production of staples.

- **Flavor.**
Generally we view the flavor of LC as something that should be kept to minimum so that other more popular flavors can dominate even when foods contain significant amounts of LC.

- **Color.**
Normally the dark green of fresh LC is a liability as is the very dark, almost black, green of dried LC. Various schemes to lighten the color or alter it (such as with Pitahaya (hylocereus ocamponis), an intensely colored dark red fruit from a cactus like plant, in Nicaragua) are worth looking into.

**Nutrition**

- **Contains Substantial Amount of LC.**
Many foods have been introduced through various projects that contained token amounts of LC. Probably 4 grams dry weight LC or 10 grams fresh per portion is a minimum if we are expecting much nutritional benefit. Malnourished children should get 25 grams fresh LC per day.

- **Doesn't destroy or bind nutrients.**
Some processes, like exposure to prolonged high temperatures or sunlight can lower the nutritional value of the ingredients in foods.

- **Makes nutrients more available.**
The addition of ascorbic acid makes it easier to utilize iron from LC. Some minerals are better absorbed in certain proportions to each other. Dried LC is more nutritious if it is ground extremely finely.
**Suggestions for 5-Day Course for Leaf Concentrate Field Workers**

<table>
<thead>
<tr>
<th><strong>Monday</strong> AM:</th>
<th>Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Leaf For Life&quot; film</td>
<td>30</td>
</tr>
<tr>
<td>Orientation</td>
<td>45</td>
</tr>
<tr>
<td>Make LC with macerator</td>
<td>120</td>
</tr>
<tr>
<td>Make and taste atol (a thick warm drink) and porridge</td>
<td>30</td>
</tr>
<tr>
<td>Agricultural aspects of LC</td>
<td>180</td>
</tr>
<tr>
<td>Questions and Answers</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Tuesday</strong> AM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Make LC with blender and with grinder</td>
<td>150</td>
</tr>
<tr>
<td>Make tamales or basic Indian dishes</td>
<td>60</td>
</tr>
<tr>
<td>Seminar on nutritional problems in developing countries and nutritional aspects of LC</td>
<td>120</td>
</tr>
<tr>
<td>Hygiene and safety</td>
<td>30</td>
</tr>
<tr>
<td>Questions and Answers</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Wednesday</strong> AM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Make LC with macerator</td>
<td>150</td>
</tr>
<tr>
<td>Make drink syrup and discuss sugar preservation</td>
<td>45</td>
</tr>
<tr>
<td>Byproducts (feeding ruminants, improving soil, biogas, ethanol and other possible uses)</td>
<td>90</td>
</tr>
<tr>
<td>Economic aspects of LC and basic calculations</td>
<td>90</td>
</tr>
<tr>
<td>Questions and Answers</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Thursday</strong> AM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Make LC with macerator</td>
<td>120</td>
</tr>
<tr>
<td>Dry LC</td>
<td>60</td>
</tr>
<tr>
<td>Social and cultural aspects of LC programs</td>
<td>90</td>
</tr>
<tr>
<td>LC machinery</td>
<td>90</td>
</tr>
<tr>
<td>Questions and Answers</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Friday</strong> AM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reporting, Records Keeping, Accounting, and Communications</td>
<td>90</td>
</tr>
<tr>
<td>Make noodles and spaghetti</td>
<td>60</td>
</tr>
<tr>
<td>Frequently asked Questions, Frequently Encountered Problems</td>
<td>60</td>
</tr>
<tr>
<td>EXAM</td>
<td>60</td>
</tr>
<tr>
<td>PARTY</td>
<td>??</td>
</tr>
</tbody>
</table>
SAMPLE EXAMINATION

1. What is the most common nutritional deficiency in the world?

2. Give 3 characteristics of plants that make good leaf concentrate.

3. Give 2 characteristics of plants that don't make good leaf concentrate.

4. What nutrient corrects night blindness?

5. Why is it important to bring leaf juice to the boiling point?

6. Name 2 things that can give leaf concentrate a bad flavor.

7. Why do women need more iron in their diets than men?

8. What is wrong with cutting leaves the evening before you process them?

9. Why is it better to heat leaf juice quickly than slowly?

10. What is the main advantage of a macerator or meat grinder over a blender for preparing leaf concentrate?

11. What other food processes can be done in a 5 gallon leaf blender?

12. Why do children not eat enough greens to provide significant amounts of protein in their diets?

13. If I process 50 kg of fresh alfalfa leaves, how much leaf concentrate should I make?

14. Which 2 of these animals make the most efficient use of the fiber left from leaf concentrate processing?
   Rabbit?    Pig?    Turkey? or Cow?

15. Why are leguminous crops like cowpeas and alfalfa good for the soil?

16. What is the biggest advantage of perennial crops over annual crops?

17. What is the youngest age that a child should begin getting leaf concentrate in his diet?

18. Which of these foods would help the body absorb iron the best?
   Tortilla?    Milk?    Guavas? or Beans?

19. Is it possible to get enough protein for excellent health without eating meat?
20. If I process 100 kg of fresh leaves with a moisture content of 80%, how much fiber should I end up with?

21. Why is calcium important to the human body?

22. What is the minimum length of time to wait before using leaves that have been sprayed with an insecticide?

23. Why is folic acid important?

24. What is the first thing to do when you come into the leaf concentrate workshop?

25. Why should leaf crops not be cut off at the ground?

26. What is neem?

27. What can bio-gas be used for?

28. What is the main drawback with very small projects?

29. What are antioxidants, and why are theory important?

30. Which of the following is most likely to improve the economics of an LC program
   a. lowering fuel use by installing a bio-gas generator
   b. saving electricity with a improved motor
   c. making the work day shorter
   d. increasing the % of LC yielded from the leaves.
OTHER LEAF CONCENTRATE PROCESSING EQUIPMENT & TECHNIQUES

LEAF PULPERS

THE BLENDER METHOD

The leaf concentrate blender is a fairly simple and inexpensive machine. It is similar to a household blender except that it has a 5-gallon or (20 liter) hexagonal container, a 1 ½-2 horsepower motor, and only one speed (3450 RPM).

Two to four liters of clean water (depending on the moisture content and toughness of the leaves) is poured into the blender, the top is fitted on, then the switch is turned on. The operator feeds the washed, cut leaves into the blender using a wooden push stick. How fast the leaves can be pushed into the blender depends on the type of leaf used and how wet or fibrous it is. The quantity of leaf that one can put into a single blender run is dependent on the same factors.

Usually about 3 kg (6.6 lb.) can be put into 3-4 liters of liquid in about two minutes. The blender should run about 20 seconds after the last leaves are put in to make sure all the leaves are ground up finely. If the leaves are especially dry or fibrous it pays to run the blender for a full minute after all the leaves are added and to use a little more liquid in processing. With a little experience it is possible to tell when to stop putting leaves into the blender by listening to the motor. As it works harder to chop the leaves it makes a lower pitched sound.

If the leaves are not coming out of the blender well pulped, you need to use more water or fewer leaves or allow them to be blended for a longer time. The leaves should be ground into homogeneous slurry. If there is a lot of liquid it means that more leaves could have been blended in the water.

Next you empty the blender into a 5-gallon bucket then let it sit a few minutes. Experiments have shown that the yield of leaf concentrate increases if the ground leaves are allowed to remain in the water for up to ten minutes before being pressed. After ten minutes there is no further gain in yields. Then you pour the bucket slowly over the press table. There are several designs for press tables. There are drawings of press tables at the back of this manual.
The blender breaks the leaf cell walls well because the hexagonal shape of the container and the leaves circulating in a liquid medium bring the leaves into repeated contact with the high speed (3450 RPM) blades. If one added 2-4 liters of water to each batch of leaves blended the resulting leaf juice would be very diluted and a great deal of extra fuel and time would be needed to heat the juice to the boiling point. This problem can be avoided by blending the leaves in juice from earlier runs. So as soon as you have a gallon (4 liters) or so of juice pressed you can begin using it instead of water as the liquid medium for blending the leaves. Whey from earlier processing can also be used but we have had some problems with it, including very strongly flavored curd. Using water for each batch will result in a slightly greater recovery of curd than using leaf juice. This is because when the juice is pressed from the blended leaves a certain amount of moisture remains in the fiber. If the moisture remaining in the fiber is pure leaf juice rather than very diluted leaf juice, the fiber will contain slightly more protein at the expense of the leaf curd or LC. Except when fuel costs are very low and leaf costs very high it is not normally economical to process the leaves only in water instead of leaf juice.

The 5 gallon leaf liquidizers are very useful for a variety of food processing tasks in addition to making leaf concentrate. They are well suited to making soymilk, which can in turn be made into tofu or soy bean curd. They are also good at preparing fruits drinks rapidly or in great quantity for group feeding situations. The liquidizers are very fast at breaking the pressed leaf curd into fine pieces for drying as well. There may be situations in which secondary uses such as these will influence the choice of leaf processing equipment.

**The MEAT GRINDER Method**

Hand operated meat grinders are inexpensive commercially available machines that do a good, if somewhat slow, job of pulping leaves for leaf concentrate preparation. Usually the meat grinders are marked with the numbers #32, #22, or #333. The #32 is the largest of the common meat grinders. The #333, the smallest, is too small for leaf concentrate processing except in the home. Any of these grinders can be powered by hand, by bicycle, or by electric motor. When they are motor driven the motor speed should be reduced to 60-80 RPM by gears or pulleys.

The mouth of the grinders should be extended at least 15 cm (6 inches) with a sheet metal guard to prevent hands from accidentally entering the grinder. A wooden or plastic push rod should always be used to push the leaves into the grinder. The push rod should have a head wide enough to prevent it from being pulled into the grinder.
The leaves should be cut or torn into pieces the length of a finger or shorter and fed slowly into the grinder to avoid it clogging. A custom made curved metal wrench that can offer some leverage is very handy for removing the retaining disc when the grinder gets clogged. The grinder powered by a motor with a speed reducer has enough torque to get very jammed up. Bits of juice and leaf are sometime shot more than a meter out of the grinder. For this reason, it is advisable to have a plastic skirt in front of the grinder to avoid getting green stains on everything.

When using a bicycle or an electric motor to power the grinder it is very important that the shaft of the grinder is precisely aligned with the power source. The speed of the motor (usually 1700 RPM) can be reduced with either gears or pulleys. The best method, but the most expensive is to use a sealed speed reducer, which has lubricated gears in a sealed steel casing. These cost between $150 - 250 US at the time of this writing. Sometimes you can buy the motor and speed reducer as an integrated unit, and this reduces the problem of alignment. However, the integrated units can be hard to work on and you may need to replace both components if one fails.

A series of pulleys can also be used to reduce the motor speed. It is less expensive but more difficult to use than the geared reducer. The pulleys must be firmly mounted and well aligned. The pulleys and the belts must be completely covered with some type of protective covering to keep hair or clothes from being caught.

You can adjust how finely the meat grinders pulp the leaves by putting in discs with different size holes. A disk with smaller holes will pulp the leaves more finely than a disc with larger holes. Unfortunately, the smaller holes also mean even slower grinding and they increase the problem of clogging. Remember to attach the grinder knife with the blades facing the disc. These knives can be sharpened periodically if necessary. After a bucket of leaves has been pulped, a liter or so of water should be added and well mixed in. The leaf pulp can then be treated the same as the pulp from the blender method.

The advantages of the meat grinders are that they are relatively inexpensive, and they can be found in a hardware store, rather than custom built. They can be used in remote regions without electricity and in homes. The meat grinders do a good job of pulping the leaves and use less water in processing than the blender method. This reduces the fuel necessary to heat the leaf juice. The meat grinders also adapt well to other food processes, like extruding churritos, mixing dough, and of course grinding meat.

The meat grinders also have some serious disadvantages. They grind leaves more slowly than blenders, hammer mills or shredders. It is expensive and complicated reducing motor speeds from 1700 RPM to 60 -80 RPM. Meat grinders work poorly or not at all with very high moisture crops like young alfalfa or mustard. Rather than being driven through the dieplate, very moist leaves are juiced in the grinder and the juice backs up and fills the grinder chamber. Meat grinders also present a danger of hands, hair, or clothes being pulled into either the grinder itself or the gears or pulleys. In addition, meat grinders are more difficult to clean than blenders.
HAMMER MILLS AND SHREDDERS

In several locations at several different scales of operation, hammer mills and shredders have been used to pulp leaves for leaf concentrate. Both machines are essentially fast moving steel hammers or blades spinning on either a horizontal or vertical shaft. The leaf crop is fed into the chamber where the spinning hammers or blades hit it repeatedly until it drops out a shoot in the bottom or side of the chamber. Often the leaves need to be passed repeatedly through the chamber to rupture enough leaf cells for good leaf concentrate extraction.

The main advantages of the hammer mills and shredders are that they can chop a lot of leaves very quickly and they don't require expensive speed reducers. There are many low cost commercially available machines that are designed to shred dry leaves to make mulch or to make animal feeds from forage or hay. Some of these can be modified to pulp fresh green leaves for leaf concentrate.

On the negative side, hammer mills and shredders don't tend to break the leaves up enough to get good yields of leaf concentrate even with several passes. After the first pass it can be a sloppy operation passing wet pulp through the machines several times. Most hammer mills are designed for grinding much drier materials and they can be nearly impossible to clean. Hammer mills are used in a lot of industrial operations and are available in many sizes. Some of these machines are very noisy to be using indoors, and most of the leaf shredders have narrow exit holes that quickly clog with wet leaf pulp. It is important to remember, however, that development work, if on a somewhat limited budget, is continuing on these machines as well as all the other possible leaf concentrate making devices.
THE LEVER PRESS TABLE

A relatively simple and inexpensive table can be built without a jack to speed up the separation of the juice from the fiber. It is useful for small-scale work. The table can be made from steel or sturdy wood, though the grate where the pressure is applied and the lever should be steel. The drawings that follow give a good idea how a press table can be built. It is possible to alter the plans somewhat to suit your particular needs, but a few important points should be kept in mind:

- The table should be at a height that is comfortable for the people that are using it.
- The lever needs to be at least 2.1 meters (7 feet) long and very stout. Smaller, lighter people need longer not shorter levers to exert the same pressure on the fiber.
- The steel bars or rods that make up the top of the lever press table need to be strong enough to resist the pressure applied by the lever. (see drawing in appendix).
- The table needs to be either bolted down or weighted to keep it from moving when pressure is applied. I prefer using sand bags for weight so the table can be moved for cleaning or reorganizing the workshop without the need for bolts in the floor.
- The workers must be able to move freely around the press table. The weight of the lever needs to be offset by a counterweight hanging from a rope on the other side of a pulley. This makes it much easier for the workers to lift the lever repeatedly. A sandbag counterweight can be adjusted to match the weight of the lever.
- The press table needs to be large enough to drain a 5-gallon bucket of pulped leaves. I suggest about 90 cm X 90 cm (3 feet X 3 feet).
- A frame made from 4 cm X 4 cm (1 1/2" X 1 1/2") wood with 6 mm (1/4 inch) metal screen firmly attached to the bottom should fit over the press table; and nylon filter cloth should be laid over this frame before the pulped leaves are poured onto the table.

- The juice needs to flow freely onto the sheet of metal or plastic under the press table, then into a bucket. The outlet of the metal or plastic sheet must be high enough to allow a bucket to be slid under for collecting the juice.

- The press table needs to be easy to clean. There should be no surfaces that will hold the juice and no surfaces that can’t be reached for easy cleaning.

Using the Press Table:

A. Make sure that the wooden frame with hardware cloth or screen is in position and that filter cloth is laid over the frame.

B. Slowly pour a 5-gallon bucket of leaves that have been pulped in a blender or in a macerator or meat grinder onto the table. If the leaves were pulped in a meat grinder or macerator they need to be mixed well with an equal volume of water before being poured onto the press table.

C. Spread the pulped leaves out evenly over the table with a smooth spreading stick or with clean hands.

D. Grab all 4 corners of the filter cloth and twist them together to make a bag with all the pulped leaves inside.

E. Place the bag you’ve just formed under the lever press with the twist facing up. Gradually apply pressure by pressing down on the end of the lever. Maintain pressure for about 10 seconds.

F. Reposition the bag and repeat this step 3 or 4 times. The leaf pulp remaining in the cloth should now be too dry to easily squeeze liquid out with your hand.

G. The press table can also be used to press the ‘whey’ from the curd that has been strained into a cotton filter bag. Pressure needs to be applied more gradually and for a longer time than when pressing juice from pulped leaves. Avoid pressing curd that is still very hot, as this tends to tear the filter bags.

H. Clean the press table well after each use.
The Motorized Hydraulic Press Table

We also made and tested a variant on this press that employed an hydraulic piston powered by a 2 HP motor. The table is designed so that a motorized hydraulic piston and the manual hydraulic jack are interchangeable by removing 4 bolts. This press seemed faster and physically less demanding than the jack press. Alfalfa pressed with this press produced slightly more curd than that pressed with the jack in a very limited test. This system clearly needed modification before we could recommend its use. Mainly we need to exchange some of the system's speed for power. The pump may need to be adjusted to match the piston's capacity. A pressure relief valve could be installed to allow the system to hold its pressure at 8 or 10 tons for a few seconds before the return stroke.

The motorized hydraulic system costs about $600-700 US more than the jack press. When the relatively simple modifications are made it should be a fast, easy to operate, batch type press. It seems unlikely that a program processing 200 kg per day could justify the additional expense, but programs working with 500 kg or more daily might find it well worthwhile. It is a system that could probably be upscaled to at least double its output fairly easily by adding T's and a second piston. The easy interchangeability seems advantageous. This way a group could begin processing with a jack and switch to a motorized piston later if production warranted it. They would then have the jack as a backup if repairs or modification in the motorized system were ever needed. Hydraulic systems are known for being low maintenance once set up. The extensive use of hydraulics in tractor work means that rural areas frequently have some people with expertise in motorized hydraulic systems. Food grade hydraulic fluid can be purchased to minimize any possibility of contamination. Quick release couplings are very useful if the piston is going to be interchanged with a bottle jack.
Small Hydraulic Jack Plate Press

A simple and inexpensive version of the hydraulic jack press table can be built from steel. It has a 30 X 30 cm press plate and uses a 4 ton hydraulic jack. Rather than use springs to return the jack to its original position, the cross beam can be pushed down against the jack after the pressure is released. Then the jack and the wooden press plate to which it is attached can be removed and the process repeated. It sits on a counter top rather than requiring a base. It is too small for general LC production but could be very useful in pilot programs, crop testing, and for doing demonstrations away from a workshop.

Hydraulic Jack Cylinder Presses

A number of relatively simple and inexpensive juice presses have been designed that use a hydraulic jack to apply pressure to leaf pulp in a perforated cylinder. Some of these utilize sturdy plastic PVC drainpipe of 15-30 cm (6-12) diameter with numerous small holes to allow the leaf juice to flow out when the pressure is applied. The pulp is held in a nylon bag that is placed inside the pipe to prevent the pulp from being driven through the holes. In another variation of this press, the chamber is metal with a fine metal screen fixed inside. Unlike the screw presses the hydraulic presses can also be used for separating the `whey' from the curd.

Some work has also been done with using hydraulic cylinders driven by an electric motor to accomplish the same thing more quickly. The motorized hydraulic presses appear to be too complex and expensive relative to how well they perform at removing leaf juice from pulp. A very similar juice press has been developed using a hand cranked arbor press rather than a hydraulic jack to apply pressure. It had very nearly the same advantages and drawbacks as the hydraulic units, though it did not apply as much pressure.

While the hand-operated hydraulic presses are fairly simple and inexpensive, they are not without what we consider to be serious problems. They tend to be slow because they are batch rather than continuous presses. Our experience has been that if the disc that is driven into the cylinder is slightly too large or too small or misaligned, it is slow and frustrating getting it back out to reload the chamber with more pulp.

Hydraulic cylinder presses tend to apply a great deal of pressure on a fairly thick layer of leaf pulp, rather than gentler pressure over a larger area. One drawback of this is that as the leaf juice is driven out of the pulp nearest the cylinder holes that pulp becomes dry enough to absorb the juice being driven out of the center of the cylinder.

A closely related problem is that the juice driven off with the initial light pressure is much richer in protein than the juice driven off towards the end with intense pressure. Some of the large protein molecules are filtered out of the juice when it is driven through
a tight mat of drier fibrous leaf pulp at the edge of the cylinder. This problem can be greatly reduced by putting a disk of grooved wood or plastic with grooves cut into them to separate layers of leaf pulp an inch or so thick in the cylinder. Then the pressure is applied to several thin layers of leaf pulp stacked on top of each other. Unfortunately, this aggravates the first problem of slow reloading of leaf.

**Screw Presses**

Several presses for separating leaf juice from fiber have been tried. One of the most frequently used employs a cylindrical screw or worm that drives leaf pulp against a screen of some kind. The juice passes through the screen and is collected on a tray that sits below the screw cylinder. Some of the screw presses are set up so that the pulped leaves remain in contact with the screen until the screw builds up a certain pressure. It then passes as fibrous residue out the end of the screw cylinder.

When they are carefully designed and tooled, screw presses are very good at separating the juice from the fiber in pulped leaves. They can be fed continually rather than in batches like the hydraulic and lever presses. On the other hand, they can be prone to clogging and can be very difficult to clean. Quite a bit of careful machine work needs to be done to make sure the clearances of the screw and the screen chamber are correct. Because of this skilled work and the cost of a motor and a speed reducer, the screw press can be a very expensive piece of machinery for a small project.

Hand operated screw presses are often used in wine presses and cider presses. In India we have combined a very heavy screw type truck jack with a table like the one described earlier (hydraulic jack press table). The advantages of hand driven screw presses is that they are extremely simple machines that are easy and cheap to maintain. One drawback of the hand-operated screw is that it needs to be manually lifted off the pulp after each run. This can become slow and tiring. The hydraulic jack press avoids this problem by using springs to lift the press plate.

Testing is currently being done with a broad flat vertical axis screw press that could mount directly under the macerator. It turns slowly, about 4 RPM, but in theory could turn the macerator into a continual process operation.

**Combined Pulpers and Presses**

One line of development in leaf concentrate processing equipment basically combines a meat grinder with a screw press into a single machine. The leaves are fed into the grinder or pulper. After they are pulped they drop into a screw press chamber immediately below. The primary advantage of this machine is that a single person in a single continuous operation can remove the juice from leaf crops. Because it has only one motor and one speed reducer, it should be less expensive than the two component machines built separately.
These machines have been somewhat disappointing in use so far. It has been difficult to adjust the relative speed of the pulper and juicer section to compensate for differing moisture and fiber content of the leaves. Many small projects don't have an adequate supply of leaf crop to justify the cost and electrical capacity of these machines. They are heavy and quite difficult to clean or to do repair work on. However, they are being constantly modified and redesigned and they may still live up to their promise of becoming a relatively inexpensive machine that can process 100 kg of leaves an hour.

Other Leaf Pulpers and Juicers

There are several other machines that have been used experimentally or in small projects to make leaf concentrate. Work is being done on a modified shredder designed by Glyn Davys that moves the leaves down a spiral series of short hammers so that they have been hit many times before they exit the chamber. Another pulper that shows great promise is based on extrusion. Here the leaves are driven through holes in a die plate by a piston arm or through holes in an outer cylinder by a revolving eccentric cylinder within. It has been calculated that the extrusion method should be the most efficient technique for pulping leaves in terms of the energy required to pulp a given weight of leaves. Village scale extruders are not available, to the best of my knowledge. It has been estimated, by workers at the University of Wisconsin, that a processing rate of about one ton of fresh leaf crop per hour would be necessary before extruders would be the leaf pulpers of choice.

A manually operated extruder was built in England by modifying plans for a Bielenburg oil press. A small amount of leaf crop is pushed into a chamber and a long lever arm drives it through a narrow slot, rupturing the leaf cells. It appeared to be too slow and physically demanding to process on more than a household level, and probably too expensive to be reasonable for that scale of operations.

The range of devices that has been called upon to remove leaf juice from the pulp is quite extensive. Modified sugar cane rollers are used in a project in Pakistan. Small screw presses designed for village scale oil extraction have also been used. Commercial machinery designed for making fruit juices has similarly been put to this use. Electric washing machines have been slightly modified to spin the juice out of the pulp. The pulp is poured into a mesh bag inside the washing machine and run a couple of minutes on the spin cycle. Often washing machines discarded because their transmissions are broken can still run on the spin cycle, making for inexpensive centrifuges. These probably present difficulties in cleaning.

On a larger scale, a few different devices have been custom built for separating juice from leaf fiber. Continuous feed belt presses may be the most promising of these. These compress the pulp between a heavy food grade belt and a perforated rotating stainless steel cylinder. The leaf juice is driven into the cylinder through the perforations and runs
out into a catch tank. The belt is held under tension between the perforated roller and another roller with heavy springs. Large scale leaf concentrate production is beyond the scope of this manual, and people interested in large scale production should contact Leaf For Life's London office.

The wide variety of custom made machinery for leaf concentrate production is an indication of the resourcefulness, creativity and dedication of the hundreds of people who have worked on this food technology since the Second World War. This ingenuity is clearly a strength; but it also reveals a serious failing. For leaf concentrate production to become economic in thousands of towns and villages in the developing world, one or two standardized designs for low cost machinery will need to be selected. Only then will it be possible to manufacture on a limited scale, rather than custom build machines. Only then will the price of equipment drop off and parts become interchangeable. Until there is some degree of standardization of equipment it will be difficult and complicated training people to use a wide variety of machines, most of which they will never see.

LEAF CONCENTRATE DRYERS

Indirect Solar Dryers

There are several designs for solar assisted tray dryers. This uses a solar collector to heat air that then rises through the chamber with the trays. The main appeal of these is that the heat source doesn't have an operating cost. Some of these types of dryers use fans to force the sun heated air over the drying trays. There are, of course, some drawbacks with solar energy as a heat source for drying LC. As mentioned earlier, leaf production tends to be best when the weather is rainy and cloudy. Even in the tropics solar energy is quite diffuse and in order to maintain relatively high temperatures (40-50°C [120 -140° F]) with an adequate airflow the solar collection area needs to be large. Glazing for large collector surfaces is difficult because glass is expensive, heavy and fragile, and polyethylene photodegrades rapidly (even more so as the ozone layer is depleted). Good insulation and sealants are not readily available in most developing countries and without them it is hard not to lose the heat collected before it flows thru the LC. The large areas involved in the solar drying of 10 -25 kgs of LC create handling problems and wind and rain protection become more expensive and complicated.

Electric Heated Tray Dryers

Similar trays were placed in a box heated with a 1500 W electric space heater and a small fan. These dryers worked fairly well with small quantities of LC, but the time and electric use were problems and the temperatures generated (c. 40° C [100 - 110 ° F]) were too low for fast drying. This dryer had the advantage of being inside the workshop so it was independent of the weather. Heavy winds and rains are serious problems for large outdoor dryers. The trays need to be arranged in such a way that the heated air passes
over each tray on its way out the vent at the top. We offset each tray 10 cm (4”) so that the air had to pass under each tray before rising to the next one. Even with offset trays, the LC closer to the source of heat will dry much faster than that furthest away in this type of dryer. It is advantageous to rotate the trays at least once during drying to move the trays furthest from the heating element in closer. This is an additional labor cost. If this rotating of trays can be done during normal working hours it is not much problem. However, often the drying will be going on in the evening after the workers have left the workshop, and having someone return to the workshop just to rotate the trays will be an irritating task.

One of the nice features of this type of dryer is that it can be hooked up to a timer and a thermostat, so that as you gain some experience in drying LC you can begin setting the thermostat for 50° C and the timer for how ever many hours you need for drying. The heater and fan can then be automatically turned off when the curd is dry even if that is in the middle of the night. This can reduce electric bills and prevent overdrying or burning of the curd. If the electric wiring in the workshop is not great or the timer, thermostat and heating element are not very well made, you may not want to be running this much electricity without someone around because of the possibility of a fire starting. The dryer we built in Nicaragua had 6 trays, each 80 X 80 cm (32 X 32”). I think it would have worked much better with a 3 kW heater. Of course, this would double the electricity usage and cost.

Many brands of electric food dryers can be purchased off the shelf in the US. Most of these are intended for household use and designed for drying a kilogram or two of fruit. Some can be expanded by adding trays. Unfortunately, because they don't add to the heating element or airflow, this simply slows down the drying. These can be purchased for $50 -500 US depending on the size and quality. The better ones have built-in timers and thermostats. These are probably only an option for very small projects or people doing experimental work.

Gas Dryers

We also made a dryer that uses gas heat rather than solar energy. This provides a measure of security against moldy or inadequately dried curd on cloudy humid days. We built this dryer to fit over a gas cooker and to use drying trays that are interchangeable with the solar dryers. It is a box of light gauge galvanized sheetmetal that captures heat from the cookers gas jets on the lowest setting. It has a capacity of about 8 kg (17.6 lb) fresh curd. After 2½ hours the LC was 6% moisture. It heated up to 70° - 80 C, which is higher than ideal for drying curd. It would probably do a better job quicker with a small exhaust fan attached to the top of the dryer. It may be possible to utilize the waste heat from heating leaf juice to power a dryer of this type, but it is difficult to keep steam from juice heating from rewetting the drying curd, unless a wall of some kind separates them.
**Tumble Dryers**

A heated tumble dryer with a fan was built in Nicaragua. It shows some promise but is a somewhat complicated gizmo with a geared motor to turn the drum, rollers, a heater, and a fan. Pete Fellows, with the Intermediate Technology Development Group, described using a drier like this with a 3 kW electric heater to dry about 3 kg of LC in a couple of hours. If you can adjust the temperature of your dryer, for example with an thermostat controlled electric heater,

the LC can be dried more quickly by beginning with a higher temperature. Temperatures as high as 70° C [158° F] will not damage the nutritional value of the LC as long as it is moist. Once the curd becomes dry to the touch, the temperature must be kept below 50° C [140° F] or some of the amino acids may be damaged and the quality of the protein can be affected. In field applications it will usually be more practical to try to hold a steady temperature near 50°C. Overheating and ruining a couple of batches of LC would quickly offset the saving in time. Generally speaking, the simpler the technology the greater the likelihood of it actually functioning in developing countries.

**CONTACTS**

**Leaf Concentrate Information:**

**LEAF FOR LIFE - USA**  
260 Radford Hollow Road  
Big Hill, KY  40405  USA  
tel-fax  606 986 5418

**LEAF FOR LIFE - UK**  
37-39 Great Guilford St.  
London, SE1  OES  
UNITED KINGDOM  
Fax 44171 261 9291

Leaf For Life - Bolivia  
Soria Galvarro 5333  
Casilla 783  
Oruro,  
BOLIVIA

Leaf For Life - Sweden  
Banergatan 85  
11526 Stockholm  
SWEDEN

Society for Green Vegetation Research  
Central Food Technology Research Institute  
Mysore 570 013  
(publishes newsletter)
INDIA

Other Organizations Involved in Leaf Concentrate Projects:

Pastoral Social- Caritas
1 de Mayo # 335
Morelia, Michoacan CP 58000 MEXICO
telefono: 52 43 12 98 90 fax: 52 43 12 10 00 52 43 12 70 40

SOYNICA
Apto RP-05
Managua NICARAGUA
FAX - 011 505 2 89 49 41

Leaf Nutrient Program, Inc. (project in Coahuila, Mexico)
1203 N. Expressway 77
Box 334
Harlingen, Texas 78552
USA

Groups Doing Related Health and Nutrition Work:

Hesperian Foundation (Publishes "Where There is No Doctor" and other excellent books for health care workers in developing countries)
PO Box # 1692
Palo Alto, CA 94302
USA

Clearinghouse on Infant Feeding and Maternal Nutrition (Publishes newsletter)
American Public Health Assn.
1015 15th Street NW
Washington, DC 20005 USA

International Vitamin A Consultative Group
& International Nutritional Anemia Consultative Group
Nutrition Foundation
1126 16th Street NW
Washington, DC USA

Johns Hopkins Hospital (Research on Vitamin A Deficiency)
120 Wilmer Eye Institute
600 N. Wolfe Street
Baltimore, MD 21205 USA
Helen Keller International  (Fights Nutritional Blindness)
15 W. 16th Street
New York, NY 10011
USA

La Leche League International  (Promotes Breast Feeding)
PO Box # 1209
Franklin Park, IL  60131-8209
USA

Related Agricultural Information:

ECHO          (publishes excellent newsletter
17430 Durrance Rd. offers small packets of seed)
North Fort Myers, Fl  33917
USA
fax  941 543 5317

Bean/Cowpea CRSP  (Publishes Newsletter)
200 Center for International Programs
Michigan State University
East Lansing, MI 48824-1035
USA

Liphatech (Sells Legume Inoculants)
3101 W. Custer Ave.
Milwaukee, WI  53209
USA

International Agriculture Sieve (Publishes Newsletter)
Rodale Institute
222 Main Street
Emmaus, PA 18098
USA

TRIADIES
Pacific Neem Project
Box E
Hakalau, HI  96710
USA
Asian Vegetable Research and Development Center  
PO Box # 42  
Shanhua, Tainan  
Taiwan,  
REPUBLIC OF CHINA 74199  
(Publishes Newsletter)

Food Processing Equipment:

Unichop  
(Inexpensive Meat Grinders)  
140 E. Commercial Dr.  
Wooddale, IL 60129  
USA  
Grace Valenti  
(Sells Pasta Machines, all Sizes)  
PO Box 105  
54-36 Flushing Ave.  
Maspeth, NY 11378  
USA

Lehman Hardware  
(low tech food processing equipment)  
PO Box #41  
4779 Kidron Road  
Kidron, OH 44636  
USA

Professor H.D. Bruhn  
(Has worked on leaf concentrate machinery for many years)  
Dept. of Agricultural Engineering  
460 Henry Mall  
University of Wisconsin  
Madison, WI 53706  
USA

INTSOY  
(Develops Soy Processing Equipment for Developing Countries)  
Dept. of Food Sciences  
University of Illinois,  
Urbana-Champaign  
1304 W. Pennsylvania Ave.  
Urbana, IL 61801  
USA

note: Many of these organizations are non-profit groups with very limited budgets. When asking for information, please enclose a self addressed stamped envelope.
BOOKS

Leaf Concentrate

Pirie N.W. Leaf Protein and Its By-products in Human and Animal Nutrition Cambridge University Presss Cambridge, UK 2nd Ed. 1987 209 pages

Agriculture and Environment


Sarrantonio, Marianne. Methodologies for Screening Soil Improving Legumes. Rodale Institute 611 Siegfriedale Road Kutztown, PA 19530 USA. 1991 310 pages

Price, Martin ECHO Development Notes ed. 17430 Durrance Rd. North Fort Myers, FL 33917-2200 USA Subscription $10 US per year


Better Pastures for the Tropics Yates Seeds P.O. Box 616 Toowoomba, Qld., 4350 Australia 1975 60 pages


**Processing**


Fellows, Peter and Axtell, Barry Appropriate Food Packaging published by Transfer of Technology for Development Amsterdam 135 pages

**Nutrition**

Cameron, Margaret and Yngve Hofvander Manual on Feeding Infants and Young Children Third Edition Oxford University Press, Toronto, Ontario Canada 1983 214 pages


Nutrition Screening Manual For Professionals Caring For Older Americans Nutrition Screening Initiative Washington, DC 1991


Management, Marketing, Training, Communications

Werner, David and Bill Bower  Helping Health Workers Learn  The Hesperian Foundation, Palo Alto, Ca.  1982


de Wilde, Ton; Schreurs, Stigntje; and Richman, Arleen  Opening the Marketplace to Small Enterprise  Intermediate Technology Publications  London  1991  155 pages

Kindervatter, Suzanne with Range, Maggie  Marketing Strategy: Training Activities for Entrepreneurs  Overseas Education Fund  New York  93 pages

Rittner, Don  Ecolinking: Everyone's Guide to Online Environmental Information  Peachpit Press  Berkely, CA  USA  351 pages
MAKING LEAF CONCENTRATE AT HOME

1. Wash and cut leaves. Use only fresh green leaves known to be edible, such as alfalfa, Swiss chard, lambsquarters, blackeye peas, wheat, mustard, kale, or collards. While many other plants make good concentrate, it is safer for beginners to stick with commonly eaten leaf crops. Wash in cool water to remove dust and dirt and cut into pieces 2 - 3" long.

2. Grind the leaves to a pulp. This can be done with a manual meat grinder or flour grinder, a wheat grass juicer, or a household blender. Fruit and vegetable juicers usually clog up quickly from the large amount of fiber in leaves. I prefer using a blender on the highest speed 1/3 full of water. This step ruptures the cell walls of the leaves liberating protein and other nutrients.

3. Press as much juice as possible from the pulped leaves. Pour the pulped leaves into a sheer nylon or polyester cloth of the type used for curtains. Squeeze out as much juice as possible. You should not be able to squeeze any juice out of a handful of this pulp when you are done.

4. Heat the juice rapidly to the boiling point. Stir very gently to prevent burning and remove from heat as soon as the leaf juice boils. A green curd should float to the top.

5. Separate the curd that forms in the heated juice in a closely woven cloth. When this wet curd has cooled squeeze the "whey" out of the curd. It should be dry enough to crumble. You may want to make a very simple press with a 2" X 4" X8' lever to apply more pressure than you can with just your hands. This can be used for pressing the juice from the pulped leaves as well.

6. What remains in the cloth is LEAF CONCENTRATE! 10 lbs of leaves should give you roughly ½ lb leaf concentrate; 4½ lbs of fiber for mulch, compost, rabbits or goats; and 5 lbs of "whey" for watering plants. Leaf concentrate can be dried at about 120° F, ground to a fine powder and stored for later use in airtight plastic bags away from any light.

Good Luck!
Macerator Components

<table>
<thead>
<tr>
<th>PIECE</th>
<th>WHERE MADE</th>
<th>ESTIMATED COST</th>
<th>ESTIMATED WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Feed Hopper</td>
<td>Local</td>
<td>$30 US</td>
<td>6 kg</td>
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<tr>
<td>2. PVC Cylinder</td>
<td>Local or Import</td>
<td>$30</td>
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<tr>
<td>3. Frame</td>
<td>Local</td>
<td>$125</td>
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<tr>
<td>4. Motor (2HP 3600 RPM) &amp; switch</td>
<td>Local or Import</td>
<td>$220</td>
<td>24 kg</td>
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<tr>
<td>5. Shaft, bearings, hub, blade and mounting assembly</td>
<td>Import</td>
<td>$300</td>
<td>10 kg</td>
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<tr>
<td>TOTAL</td>
<td></td>
<td>$705</td>
<td>70 kg</td>
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</table>

IMPACT MACERATOR
(measurements in inches; 1 inch = 25.4 mm)
Assembly of Macerator

1. You can purchase piece #5, the shaft, bearings, hub, blade and mounting assembly from Leaf For Life for $300 US plus shipping. This includes a heavy stainless steel shaft, two bearings, (the top one being nickel plated food grade), a mounted pulley and 12.5 mm (½") high density nylon blades covered with 16 gauge stainless steel. These are set in a steel bearing support that can be welded to a locally built frame. This assembly also includes an aluminum cover to protect the drive belt. This is the only piece that is difficult to build locally in many locations.

2. If you decide to purchase this assembly follow the steps below:
   a. Disassemble the bearings and aluminum cover, noting how they fit back together.
   b. After welding the bearing support to the built frame, reassemble the aluminum cover and bearings. Any lips or edges of the aluminum cover should face down to collect the least amount of pulp.
   c. Before mounting the cylinder and cylinder supports, assemble the blade and mount it on the shaft. This allows for the correct positioning of the cylinder. There should be about 6.25 mm (1/4") between the tip of each blade and the inside cylinder wall.

3. For safety make sure the drive belt is covered both under and outside of the cylinder.

4. The outside diameter of the blade shaft pulley is 70 mm (2.8"). The pulley on the motor should be the same size or as close as possible. If the pulley on the motor has a much larger diameter it will cause unacceptable vibration.

5. The motor should be a good quality two horsepower 3450-RPM electric motor. Most motors this size can be set to run on either 110 Volt or 220 Volt current. Make sure that the motor is set for the wall current that you are using. If you have the choice use, 220 Volts as the motor will run cooler and last longer. Also be sure that your motor is built for the frequency of electricity that you will be using. Most of the world uses 50 Hz frequency, but the United States, Mexico and parts of Latin America use 60 Hz. A 60 Hz motor running on 50 Hz electricity will run about 17% slower and will overheat easily.

6. A plastic washtub as large as will easily slide under the pulley and belt should be used. For a smooth operation you'll probably want two or three of these, so they can be switched quickly without stopping the leaf pulping.

7. You may want to attach flexible plastic flaps to the frame to prevent bit of pulp from flying out over the top of the washtub. This is especially important if you plan to use the macerator to granulate leaf curd as well as pulp leaves.

8. To reduce noise, vibration, and movement of the macerator, rubber feet of some type should be fitted to the legs of the frame. The frame should also be secured to the floor or a wall in some manner.
## Monthly Report Form

<table>
<thead>
<tr>
<th>Date</th>
<th>Kg Leaf Crop</th>
<th>Kg Leaf Concentrate</th>
<th>Kg Fiber</th>
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ABOUT THIS MANUAL

It is the purpose of this manual to help people interested in health, nutrition, agriculture and environmental issues to be able to begin making and using leaf concentrate in towns and villages in developing countries. This manual is an ongoing work that will be periodically updated. It deals almost exclusively with small or village scale production systems. There is very little information on industrial scale production. This manual should be useful to anyone involved in a small leaf concentrate program, but is not intended to substitute for hands on training. Eventually, the manual will be matched with a training film on videocassette and a 3 - 5 day training course offered at least once a year. You may want to photocopy some of the information and charts in this manual for people who need to refer to one aspect of leaf concentrate work, but who do not need the entire manual.

Throughout the manual I use the terms "leaf concentrate", "LC", or occasionally "leaf curd" to describe a food made from coagulating green plant leaf juice. This food has also been called "leaf protein" and "leaf protein concentrate". Most of the references relate to projects linked with or run by a small voluntary organization called Find Your Feet in Great Britain and Leaf for Life in the USA.

Information and ideas for this manual came from a lot of people, most importantly Walt Bray, Glyn Davys, and Boone Guyton. Drawings and help with layout also came from several people, including Beth Rosdatter, Alison Craig, Susan Lynn, Therese and Sherri Hildebrand, Jose Leon and Danne Lakin. You are most cordially invited to join in the development of this exciting 'Food for the Future'. Leaf For Life appreciates any criticisms or suggestions that may help to improve this course. We also like to hear of problems, solutions, recipes, or good ideas that people run into while working with leaf concentrate.

Thank you and the best of luck.

INTRODUCTION

In the last half of the 18 th Century a Frenchman named Rouelle discovered that a vegetable curd could be made by simply heating the juice squeezed from hemlock leaves. Little was done with this information until World War II when the British, fearing that their food supplies could be cut off, began searching for alternative sources of protein. N.W. Pirie led a team of scientists in the development of equipment to extract protein from green leaves. Using alfalfa, wheat leaves, mustard greens, and other plants, the team did a great deal of research on the use of these leaf concentrates. While this team and a few other individuals continued working on leaf concentrates, it wasn't until the 1960's that interest in making curd from leaves picked up again. Work began advancing on two quite different fronts.
In several highly developed countries work began on using dried leaf curd to enrich animal feeds. At the same time Find Your Feet (LEAF FOR LIFE), a small voluntary organization based in London, England, began promoting the use of leaf concentrate to counter malnutrition in children living in tropical villages and towns.

Several studies were undertaken to establish the safety and nutritional value of the leaf concentrate in the diets of children. Find Your Feet (LEAF FOR LIFE) has since started programs to teach women how to prepare leaf concentrate for malnourished children in Mexico, India, Bolivia, Sri Lanka, Ghana, Nicaragua and Bangladesh. These programs have received financial support from the United Nations, the European Economic Community, Mexico's DIF, the British Overseas Development Agency, the Rotary Club International, employee programs from Delta Airlines and Sun Microsystems, as well as many private trusts and individual supporters.

In all of its projects Leaf For Life has worked to train women to make high quality leaf concentrate from local leaves, with the aim of improving the diet of members of their communities who are vulnerable to malnutrition. Usually this means children, pregnant and nursing mothers, and the elderly. Through the work done in these projects and work done in England, the U.S., India and Sweden the process of making and using leaf concentrate is gradually becoming easier and more economical.

Machinery is constantly being improved and new recipes are tried every year. The workshops where leaf concentrate is made are becoming more efficiently organized and the cost of starting a program is dropping.

* We know of two other organizations using leaf concentrate in small nutrition programs. Leaf Nutrient Program has begun a project in Coahuila, Mexico and the Pakistan Council for Scientific and Industrial Research did the same type of work at an orphanage near Lahore, Pakistan. Their addresses, along with those of other sources of information on subjects related to leaf concentrate are listed in the back of this manual.

**WHAT IS LEAF CONCENTRATE?**

Leaf concentrate is an extremely nutritious food made by mechanically separating indigestible fiber and soluble anti-nutrients from much of the protein, vitamins, and minerals in certain fresh green plant leaves. Because it is so rich in beta-carotene, iron, and high quality protein, leaf concentrate is very effective in combating malnutrition, especially the anemia and vitamin A deficiency which are prevalent among children and pregnant women in most developing countries. It is easily combined with a variety of inexpensive foods to make culturally acceptable dishes.
Because it takes more direct advantage of solar energy, a leaf crop can produce more nutrients per hectare than any other agricultural system. Leaf crops can usually be produced with less environmental impact than grains. The simple technology of making leaf concentrate offers a means of capturing a much greater part of the leaf harvest for direct human consumption. The fiber that is separated can be used to feed animals, and the left over liquid, or "whey" can be used to fertilize plants, so nothing is lost.

**WHY LEAF CONCENTRATE WORKS**

Agriculture is basically a biological system for collecting the energy of the sun in ways that are useful to humans. Green leaves are the solar energy collectors. The more surface area of green leaves exposed to the sun's light, the more energy can be captured from a given parcel of land.

Chlorophyll, the pigment that makes leaves (and leaf concentrate) so green, converts carbon dioxide from the air, water and sunlight into simple carbohydrates. These combine with each other to make sugars and starches, which supply our bodies with energy. They also combine to make fibers like cellulose and lignin that make useful things like paper, cotton cloth, and wood possible. These simple carbohydrates formed in the plant's green leaves also combine with nitrates from the soil to make proteins, which are often called the building blocks of life.

The basic foods that we eat are almost all created in the green leaves of plants. They are then translocated to be stored in seeds, tubers, and fruits. When we eat a tortilla, a sweet potato, or a banana we are eating food made by the green leaves of the corn plant, the sweet potato plant, and the banana plant. Moving the food from the leaf to the seed or the tuber or the fruit costs the plant energy. This reduces the amount of available food because the plants burn their own sugars and starches to get this energy. Of course, much more of this food becomes unavailable when the seeds or tubers are fed to animals. This explains why animal products like meat, milk, and eggs are usually more expensive than plant products.

When we grow wheat or other basic grains the young leaves of the plant are relatively efficient at converting the sun's energy to food. However, for much of the time that the grain occupies our best farmland it is producing very little food. As the leaves turn yellow and brown they stop producing food and the plant is simply drying the seed so that it will be a very compact food storage container. These grains are certainly convenient food. Because the grains have far less water and fiber than the green leaves, as well as generally milder flavor, they have been a more useful and popular food.

The leaf concentrate technology offers a simple means of removing much of the water and almost all of the fiber from the green leaves. This can make green leaves a much more attractive food. While leaf concentrate will never replace grains, it does offer a major
new source of food in the human diet. Combining inexpensive easily grown starchy crops like cassava, bananas, and breadfruit with leaf concentrate could provide superior nutrition to a grain based diet for millions of people in the tropics. By more directly tapping the tremendous productivity of leaf crops, leaf concentrate can produce more protein and most other important nutrients per hectare than other agricultural systems.

How quickly this food technology is put into widespread practice will depend mainly on economics. The economics of leaf concentrate production is closely tied to the scale of operation and how well the fiber that remains when the concentrate is separated from the leaves is utilized. Usually the most economical use of this fiber is to feed it to cows, goats, sheep, horses, rabbits, or guinea pigs. Because the fiber is so finely chopped up animals can absorb the nutrients in it more readily than they can from hay or forage crop. In a sense, the grinding of the leaves for making leaf concentrate acts in the same way as the animals chewing the leaves for a long time. This residual fiber is also lower in moisture than the original leaf crop so it is easier to dry for hay or to preserve as silage.

Ultimately what makes leaf concentrate work is that it is based on the careful observation of some of the biological processes that are fundamental to understanding the nature of food. How well it works will be determined by how well people like yourself can apply these observations to create practical systems of leaf concentrate production.

ADVANTAGES OF LEAF CONCENTRATE

1. Leaf concentrate is an extremely nutritious food. It is richer in vitamin A and iron than any commonly available foods. Deficiencies of these two nutrients are two of the most serious and prevalent health problems in the world today. Leaf concentrate is also a very good source of high quality protein and calcium, as well as several other important nutrients.

2. It is a very efficient way of using land to produce food, yielding roughly three times as much protein per hectare as grain crops and five to ten times as much per hectare as animal raising.

3. While the green color of leaf concentrate foods is unfamiliar, the acceptance of these foods by children in a dozen different countries has been excellent. As most parents know, many children all over the world do not like to eat dark green leafy vegetables. We do not have this problem when these leaf crops are converted into leafy concentrate foods.

4. Leaf concentrate is relatively easy to make. It can be made in rural villages, by people with little training or education.
5. It offers a very nutritious food at prices below what foods like meat, cheese, eggs, or powdered milk cost. It is usually the cheapest dietary source of vitamin A and iron wherever it is made.

6. It is an environmentally sound agricultural technique. Leaf crops protect the soil from the erosion that has been destroying grain production land. Pesticides are not needed to protect leaf concentrate crops from cosmetic insect damage since the leaves are ground to a pulp immediately after harvest.

7. Nothing is wasted in leaf concentrate production. The residual fiber makes an excellent feed for cows, goats, sheep, horses, rabbits, or guinea pigs. It can also be used to enrich the soil or in production of bio-gas for cooking. The left over liquid is rich in nitrogen and potassium, and makes a good fertilizer. It has been used to produce ethanol as well.

8. Unlike dark green vegetables, leaf concentrate is easy to preserve. It can be dried, converted to pasta, made into drink mixes or syrups, salted or pickled.

9. Many of the anti-nutrients found in leafy foods are removed through the leaf concentrate process. The hydrocyanic acid, nitrates, goitrgens and free oxalic acid that limit the usefulness of many leaf crops in the human diet are almost completely removed when the leaves are converted to leaf concentrate.

10. Leaf concentrate uses far less fuel to prepare than beans, the main high protein food of the world's poor.

11. There have been no known cases of allergic reaction to leaf concentrate since 1975 when the standard processing heat was raised to a minimum of 90 °C (195 °F). However, many children are intolerant of other nutrient dense foods like fish or cheese, and genetic lactose intolerance makes milk a less than ideal food for children in some regions.
DISADVANTAGES OF LEAF CONCENTRATE

1. Good leaf yields require a steady supply of water. In many locations there are long dry seasons and irrigated land is at a premium. In arid lands the water requirements of lush leaf crops are usually excessive and focusing on improving water thrifty crops like sorghum, millet, buffalo gourd, tepary beans, and acacias is a more realistic strategy.

2. Most people are not accustomed to eating many dark green foods.

3. Fresh leaves are very perishable. They must be processed soon after they are harvested or the quality and yield of leaf concentrate goes down.

4. Fresh leaves are heavy as is the residual fiber and 'whey'. These means transportation costs will be high unless processing can be done very close to the leaf crop field.

5. While domestic scale production can be done with inexpensive commercial grinders and blenders, larger scale equipment is not currently available commercially and must be custom built.

6. The vitamin C in fresh leaves is lost during processing.
SECTION I

HOW TO MAKE LEAF CONCENTRATE

EIGHT BASIC STEPS

1. Harvest fresh green leaves from plants known to be good sources for leaf concentrate. (More information on choosing the right plants is in the section on growing leaf concentrate crops in this manual).

2. Wash the leaves well in clean water to remove dust and dirt.

3. If the leaves are large or there are a lot of tough stems cut or tear the leaves into pieces the length of a finger. (This step is unnecessary with some of the leaf grinders like the impact macerator)

4. Grind the leaves to a pulp.

5. Press as much juice as possible from the pulped leaves.

6. Heat the juice rapidly to the boiling point.

7. Separate the curd that forms in the heated juice in a tightly woven cloth.

8. Press as much liquid as possible out of this curd.

What remains in the cloth is LEAF CONCENTRATE
1. **Cut fresh green leaves**  

**HARVESTING LEAVES**

Normally we prefer to harvest leaves early in the morning and take them immediately to the leaf concentrate workshop where they are washed in clean water then ground up as soon as possible. Any long delays in processing from the time the leaves are cut until the leaf concentrate is finished will lower the quantity or quality of the final product.

The leaves are cut off as low on the plant as will allow for rapid regrowth. It is very important not to cut too low, especially with plants like cowpeas, as they will die rather than produce more foliage. Cutting cowpeas at 5 cm rather than 20 cm (2 rather than 8 inches) will mean that the crop needs to be reseeded at least twice as often and the annual leaf production will be several tons less per hectare. The ideal height for cutting leaf crops varies from crop to crop and even among varieties of the same crop. It is relatively easy to test regrowth at a few different heights to see what works best with the crop you are using.

Perhaps more important than the height at which a crop is cut, is the time. Leaves are best for making leaf concentrate when their content of protein is highest and their moisture content is between 75-85%. As a very general rule, for most crops their leaves are at peak moisture content early in the morning and a peak protein content just before flowering. A schedule of harvesting can be worked out that takes into account seasonal fluctuations of leaf production as well as any changes in the processing capacity or end use of leaf concentrate that take place during the year.

Equipment for harvesting leaf concentrate for small scale projects is very simple. A Nicaraguan leaf concentrate worker developed a handy cutting system using a sharp machete and a special stick with a curved metal hook on the end. He uses the hooked stick to hold the plants erect to cut with his machete and then to toss the cut plants into piles. Generally two handed scythes or swing blades are more effective for cutting alfalfa and most other leaf crops than machetes or knives. Cowpeas tend to get too tangled to cut with a scythe, but with a little practice this is a much faster method for cowpeas as well. European scythes are often made with better blades and better balance than cheaper stamped steel ones available in the US and many other countries.
On a slightly larger scale a sickle bar or reciprocating mower could be used to cut the crop. Several implement companies make sickle bar mowers that will slice the leaves off cleanly at an even height. This height may be lower than optimal for some crops and may need to be adjusted. Some of these are designed to be used with tractors or horses, but there are also some designed for use with "walking tractors" like the BCS or the Gravely, that are smaller, cheaper, and more flexible in use than larger tractors.

One type of leaf cutter that doesn't work for leaf concentrate is a rotary lawn mower. These have high speed rotary blades that chop the leaves too finely before they can be washed. The rotary motion also tends to suck up dirt and dust that are very hard to wash out of the cut leaves. Some early tests of leaf concentrate showed very high levels of ash because the leaves were cut with a rotary lawn mower and the dust was never adequately removed.

Strimmers or Weed Eaters can also be useful for leaf harvest. There are a wide range of these tools available with different cutting heads and we have not tested them thoroughly. Michael Cole in England uses a strimmer with a metal cutter for alfalfa. We are trying to employ a Strimmer fastened to small bicycle wheels for wet weather weeding in Nicaragua, and it is possible that this technique can be employed in leaf harvest as well.

**Transporting Leaves**

After the leaves are cut they are usually tossed into piles. Using light leaf rakes to pull the harvested crop into windrows and hayforks to load them onto carts is much faster than packing the leaves into sacks by hand. The piles are then picked up and loaded into sacks or piled directly into a cart or wagon or truck. Whatever is most convenient for your project to haul the leaves is probably fine.

We have had some problems with bicycles and with trucks. The bicycles don't have the hauling capacity needed and sometimes the amount of leaf concentrate we could make was limited by what could be hauled on one bike trip. The three wheel bikes designed for hauling could be better, but they are made for paved streets and won't do well getting in and out of muddy fields. We found that trucks tend to be too valuable and have many other competing uses. The use of trucks may be freely offered at the beginning of a new project when enthusiasm is high, but they can become much less available after the novelty of the program or the presence of foreigners passes. They are frequently broken down, even if otherwise available.

Wheelbarrows and simple two wheel push carts may work well if the amount of leaves is not great and the distance between the leaf field and processing workshop is only a couple hundred meters. For greater weights or greater distances carts drawn by horse, donkey or ox may be more appropriate. The cost of transporting leaves should definitely be figured into your economic projections. You may be able to offset some of the cost by offering some of the residual fiber to the owner of the animals for feed. If fiber and "whey" need
to be hauled somewhere, it may be reasonable to arrange for them to be hauled away by
the same cart that delivers the fresh leaves.
In wet weather carts can bog down in the mud and leaves may need to be packed into
sacks and hauled to the road on workers' shoulders. Wider tires such as automobile tires
don't bog as easily as bicycle tires, but they add a lot more weight and friction to the load.
Motorcycle tires may be a good compromise in areas where inexpensive used ones are
available.

Transportation of leaves is one of the most commonly underestimated expenses in leaf
concentrate projects, and it is well worth giving some thought to this at the initial planning
stage.

**Weighing Leaves**

After the leaves are brought into the workshop they should be weighed. The leaves can be
weighed with a bathroom scale, a fishhook type scale, or a scale used for weighing grain
and feed. Weighing leaves and recording the weight every day may seem like an
unnecessary bother, but it provides projects with important information. If the leaves and
the leaf concentrate are weighed every day it becomes possible to analyze labor costs,
processing efficiency and other aspects of production critical to an economically healthy
program.
If you are buying leaves, it is normally better to buy them by weight than volume as it
relates more directly to yield. Don't pay extra for leaves that a farmer has hosed down, as
the water will not yield any LC. By correlating leaf weight with LC weight, you may be
able to see that a certain type of leaf crop is more economical, or that leaves from one
farmer are a better buy than those from another. Changes in the ratio of LC produced to
the weight of the leaves may alert you to problems with machinery, processing, or
agricultural technique.

**2. Wash the leaves**

Once weighed, the leaves should be inspected for pieces of stick, roots, and rock. It is
usually not necessary to remove weeds, grass, or dead leaves. Only when there are a lot of
weeds known to be poisonous or very bitter tasting is it worth the trouble of picking out
every one. In several projects the extremely careful picking out of stray weeds and bits of
grass was taking more time than grinding and pressing the leaves, and providing no
benefit.

After inspection the leaves should be immersed in clean water to remove dirt and dust.
This can be done in large washtubs or in specially designed wash tanks. Small amounts of
leaves can be washed by hand then shaken out to remove excess water before cutting and
grinding. For larger quantities of leaves you will probably want to use a special tank and
handle the leaves with clean pitchforks or rakes. In either case you want to remove the leaves from the tank rather than drain the water and then remove the leaves. When the water is drained much of the dirt gets caught in the leaves on its way out. If you can't grind the leaves right away for any reason, try to leave them in the wash tank, as this will delay wilting which lowers leaf concentrate yield.

Where water is in short supply you may want to use this water at least once more. It can be used for the initial rising out of pots, filter cloth and processing equipment. Ideally it could then be used to water crops. If a crop field, orchard or garden is downhill from the processing site it may be worth running a tube or a ditch to carry this wash water to plants. It is important that the wash water not be repeatedly drained very near the workshop or the soil will quickly become waterlogged and foul smells will follow. It could also become a breeding ground for mosquitoes that can spread malaria, dengue fever and other diseases in tropical areas.

3. **Cut or tear the leaves into pieces**

Depending on the crop and the type of pulping equipment used, it may be necessary to cut or tear the leaves into smaller pieces before pulping them. This step reduces the work that the pulper must do and may eliminate long fibers wrapping around machine parts. Precutting leaves also makes feeding the crop into leaf pulpers easier. Vine crops especially are difficult to feed into leaf pulpers if they are not cut to shorter length first. Some tropical legumes have vines several meters long that tend to get very tangled.

Precutting the leaf crop can be done with a forage chopper. These can be treadle powered, bicycle powered or motor driven. Relatively small amounts of leaves (up to about 200 kg can be cut on a table with a machete or cutlass. This is tiring work, and the likelihood of accidents increases as people become fatigued from heavy exertion. Very small quantities of leaves can be stripped from their vines by hand. This is very slow, but worthwhile on a domestic scale where leaves are pulped with manually operated equipment.

Precutting leaves adds a time and energy consuming step to the leaf concentrate process. This step often takes longer than pulping. It may also require additional machinery, such as forage choppers. Whenever possible it is advantageous to avoid this step. The impact macerator is a leaf pulping machine that can handle fairly long fibrous leaf stems (alfalfa up to 70 cm [28"] without precutting. This is one of the main reasons we are currently advocating use of the impact macerator for small leaf concentrate programs.

4. **Grind the leaves to a pulp.**

Perhaps the most critical aspect of economic leaf concentrate production is the pulping of the fresh leaves. In order for juice to be squeezed easily from the leaves they must be well ground. There are a number of ways to do this, several of which will be briefly described in this section. However one goes about pulping the leaves, the object is to break open as
many of the leaf’s fibrous cell walls as possible. When these walls are broken open the nutrient rich contents of the cells can pass into the juice and later be recovered as curd.

When leaves wilt, the pressure inside the cells is reduced and the amount of force required before rupturing the cell wall increases; just as it is easier to pop a fully inflated balloon. The yield of LC from most crops will decline 4-15% in 4 hours and by 50% after 9 hours. Even with ideal circumstances, it is impossible to rupture all the cell walls, but some techniques work far better than others. If clearly recognizable pieces of leaf remain after pulping, cell rupture is inadequate.

Generally smashing leaves works better than cutting them repeatedly. Pulping the leaves takes several times more energy than pressing the juice out. It is usually uneconomical in terms of energy to try to squeeze juice from leaves that have not been ground up first.

Several studies on industrial scale leaf fractionation have shown extrusion, or the driving of leaf crop through small openings, to be the most energy efficient means of rupturing leaf cells. Smaller scale extruders have not performed as well. Probably extrusion is superior to other methods of cell rupture only when over one ton per hour of leaves is being processed. On the other extreme leaf crop can be pulped with hand operated grinders. We do not normally recommend this because it dooms the operator to a very low hourly productivity.

There is currently no off-the-shelf machine that is designed specifically to make leaf concentrate. There are some machines like hammer mills and meat grinders that can be fairly easily adapted to the purpose. In choosing a machine to pulp leaves it is worth considering at least the following:

- **cost** and availability
- **throughput** (how many kilograms of leaves can be processed per hour)
- **clean up time** required (this can be a significant hidden labor cost)
- **dependability** and ease of maintenance (a 100 kg per hour machine that has a lot of down time may produce less per month than a more dependable 50 kg per hour machine.)
- **energy use** (what is the cost of energy per kg of LC produced? Does it use a form of energy readily available? 3 phase electric motors are generally more efficient than single phase, but only if 3 phase current is available where you are working)
- **safety** and noise level

A number of different leaf pulping machines have been tried in village programs. Some of these are discussed in the chapter on Other Leaf Concentrate Processing Equipment on page 149. **Below is some information on the leaf pulping machine that we currently recommend using in projects that process over 100 kg and under 1000 kg of leaf crop per day. Drawings are on page 175**

**The Impact Macerator**
The main pulper that we use is a modification of a tool developed at the University of Wisconsin in the US by Richard Koegel and Hjalmar Bruhn. It is basically a vertical axis hammermill with a single fixed hammer. Leaves are dropped into a large feed hopper that directs them to the center of the blades. They spin at approximately 3450 RPM inside a 350 mm (14")* cylinder made of steel or very heavy gauge PVC. (* Measurements are mostly approximate metric equivalents of work done in the English system). The leaves are smashed by the blunt blades and fall through to a 58 X 35 cm (23 " X 14") plastic washtub sitting below the cylinder. The cylinder sits on a frame of 50 mm (2") square steel tube. A two horsepower high speed motor is mounted vertically between the legs of the frame.

In the original design the macerator was driven directly from the motor shaft. Driving the macerator with a pulley instead allows the placement of the motor outside the cylinder so that only the belts and pulleys need to be covered. It also allows for the macerator to use a greater variety of motors that may be less expensive, and to use gasoline or diesel motors where electricity is not available. A pulley driven macerator has to have bearings on the shaft the blades are attached to and some means of preventing pulp from piling up on the belt shroud. One advantage of the direct drive is that the motor bearings are the only ones needed. It is quite possible that the motor bearings would last longer, however, if the shaft had its own set of bearings. In addition we can use nickel plated food grade top bearing, which makes for a more hygienic process. The external powered macerator is quite a bit quieter.

The power is transferred from the motor by way of a set of pulleys and a fan belt to a 250 mm (1") stainless steel shaft. The shaft passes through two bearings separated by about 125 mm (5") of steel support. The top bearing is of sealed nickel plated food grade materials since it comes in contact with the leaf crop. About 95 mm (3 3/4 ") above the top bearing a blade is mounted on a stainless steel hub that is fixed to the shaft with 2 Allen screws set at 90° from each other.

The blunt blades or hammers are a cross of high density nylon (Nylamid) 37.5 mm wide X 12.5 thick mm X 338 mm long; (1½ " , ½", and 13 ½ "). The hitting surface of the blades is covered with stainless steel of 16 gauge. This cover is bolted through the top of the blade with 6.25 mm (1/4") stainless steel bolts with lock or pressure washers. The stainless steel cover gives much greater abrasion resistance to the blades without the weight of solid stainless steel blades.

The PVC cylinder sits on the very inside edge of the frame, and is held in place by four 4" angles extending from the corners of the frame. Two 7.75 mm (5/16") bolts with wing nuts prevented the cylinder from vibrating. We use a cylindrical galvanized sheet metal feed hopper. It is a 425 mm (17") in diameter, and 400 mm (16") high; with a shallow cone attached that ends with an 200 mm (8") opening about 100 mm (4") over the center of the blades.
It is necessary to pass the leaves through the macerator twice in order to achieve adequate cell rupture. Tests in Mexico using alfalfa indicate that with two passes the macerator grinds the leaves about as well as a 5 gallon liquidizer, and it does so in considerably less time. The macerator doesn't require precutting the leaf crop, a time consuming step that is necessary with many small scale leaf pulpers. Alfalfa 70 cm (28”) long passed through without problem. The macerator also eliminates the handling of liquid that is necessary with the 5 gallon liquidizer.

This macerator can pulp over 100 kg of leaves per hour even with two passes. A bit of experience is needed before workers can match the flow of leaf crop into the macerator with the machine's capacity for maximum throughput. This is especially true on the second pass where big clumps of pulp can overload the motor. A third pass improved the yield of LC further, but is probably justified only where leaf crop is very expensive.

We are still testing this machine and it is quite likely that the exact configuration of the blades, blade speed, cylinder size, feed hopper, and motor capacity that we recommend will be adjusted as we learn more about this machine. However, a few patterns emerged that were quite consistent. Adding water to the pulp always improved yield, though it doubled cooking time and fuel consumption. This is a technique where water equivalent to ½ of the volume of the leaf pulp is mixed with the pulp and allowed to sit for about ten minutes before pressing. The higher the blade speed and the slower the feed rate, the higher the yield was. Very high blade speeds led to unacceptable vibration and noise.

5. **Press as much juice as possible from the pulped leaves**

After the fresh leaves are ground up or pulped the juice must be separated from the indigestible fiber. This is usually accomplished by pushing the pulp against a fine screen or a filter cloth that allows most of the juice to pass through but holds back the pieces of fiber. A thin layer of pulp (less than 4 cm [1½""]) works far better than a thicker layer. When a thicker layer of pulp is pressed much of the juice from the center of the layer tends to be reabsorbed by the drier pulp at the edge of the layer. Some of the large protein molecules are also filtered out when the leaf juice must pass through a thick layer of compacted pulp to escape. This lowers the yield of leaf concentrate. Very high pressure is unnecessary and can complicate things by clogging filters. A pressure of 2 kg per cm² (30 lb. per inch²) applied over a layer of leaf pulp that is initially 2.5 cm (1”) thick for ten seconds is usually adequate. Pressures as low as one third of this can be effective if the pulp is reoriented and pressed a second time. After pressing it should not be possible to get more than a drop or two of liquid from the fiber when it is squeezed in your fist.

**Below is some information on the juice press that we currently recommend using in projects that process between 100 kg and under 500 kg of leaf crop per day.** Some of the other machines that have been used to press leaf juice are described in the section on
other processing equipment, page 153. Drawings of several of the presses described are in
the appendix.

THE Hydraulic Jack PRESS TABLE

The hydraulic jack press table works by spreading a layer of pulped leaves over 60 X 60
cm (24" X 24") surface, 3-5 cm (1-2") deep and applying pressure over that area with a 12
- 20 ton hydraulic truck jack. After the juice is pressed out, the jack and the wooden press
plate it sits on are returned to their original position with 2 stout springs. It is worth trying
to get the jack set for the minimum return that will allow the pulped leaves to slide
underneath. This will reduce the time consuming effort of using the jack handle to bring
the press plate into contact with the leaf pulp. The press plate should be covered with thin
stainless steel or galvanized sheet metal.

A table is built with 2" thick wood under a galvanized tray that has 2 - 4 layers of rabbit
cage wire fence or some plastic fencing material on top to allow the leaf juice to run off
freely. It is worth having a good jack that can be easily rebuilt. Enerjac, Hein-Werner, and
Lincoln make professional quality 12 ton bottle jacks that are available in the US. Jacks
may need to have air bled out of them every three months. Most jacks have a rubber
nipple that can be removed for this purpose.

The galvanized tray is large enough to hold two 60 X 60 cm (24" X 24") wooden frames
that have 62 mm (1/4") woven wire mesh (hardware cloth) fixed to their bottom side. This
allows the press operator to fill one tray while the other is being pressed. The tray needs to
be inclined enough for the juice to flow freely into a bucket.

The complete press table cost about $350-400 US built in Mexico. With a little practice it
does a good job pressing loads of 6 kg of leaves. It has a capacity of about 50 - 75 kg per
hour. For projects processing over 200 kg of leaf per day a motorized version of this
press, described on page 155 may be more appropriate.

Strain the Leaf Juice

The leaf juice should be strained through a screen or cloth before heating to remove
particles of fiber. If a significant amount of fiber is left in the leaf juice the appearance
and the nutritional composition of the concentrate will be somewhat altered. Small
amounts of fiber are usually not a problem in the diets of adults. For children in
developing countries whose diet is already high in fiber, however, fiber can aggravate
diarrhea and make some nutrients more difficult to absorb.

6. Heat the juice rapidly to the boiling point.

Leaf concentrate is separated from the leaf juice by coagulating the protein. When the
protein coagulates many other nutrients are pulled together in this curd. The most
effective way to coagulate the protein in leaf juice is to heat it rapidly. While the leaf curd
or concentrate will form by the time the leaf juice reaches 65° C (147° F), it is very
important to continue heating the juice to the boiling point. This serves several purposes, including:

- **pasteurization** of the leaf concentrate to kill most harmful microorganisms that may have been on the leaves from the soil or from handling.
- **destruction of enzymes** in leaf juice that can lead to off flavors, and more rapid deterioration of the concentrate, as well as to the formation of pheophorbidess. These substances can cause sensitivity to light and allergic reactions in some people.
- **formation of a firmer curd** that is much easier to separate from the leaf juice than the soft curd that forms in juice that is not heated to boiling.

Heating should be as rapid as possible. Heating slowly will cause a reduction in yield. It also causes the curd to be soft and fine textured. This type of curd is undesirable because it seals up filter cloths that are used to separate the curd from the remaining liquid ("whey"). Slow heating also results in greater fuel costs as more heat is lost to the air. It is not necessary to keep the leaf juice at a boiling temperature. Holding the juice at the boiling point for more than a few seconds will cause some loss of vitamins as well as greater fuel costs, without providing any benefits.

The simplest way to heat leaf juice, and the method we use most often in small projects, is to put it in a large shallow pan over a hot flame. This is a very familiar process to peasant women who generally bring liquids to a boil over fires several times a week. The pot should have a top to conserve heat.

Heavy gauge stainless steel is the best material for the cook pots to be made from in terms of cleaning and not contaminating the juice. Aluminum pots are generally much cheaper and more readily available than stainless steel. Light gauge pots of any material should be avoided because there will be more problems with curd burning on the bottom of the pot. Burning of curd can be greatly reduced by gently scraping across the bottom of the cook pot a few times just before the juice reaches the boiling point. It may be helpful to use the same amount of juice each time you heat so that you can time how long it takes to come to a boil. For example in Mexico we have been heating about 18 liters in a 30 liter pot. It takes about 13 minutes to come to a boil using a high pressure gas burner. We can use an inexpensive kitchen timer set at 11 minutes so that we don't have to constantly watch the pot. When the timer buzzes someone will take off the lid and begin gently scraping the bottom of the pot. This prevents boiling over, and reduces burning curd and unnecessary fuel use.

Gas fires are sometimes not hot enough for efficient curd formation. This may be due to a regulator keeping the pressure too low or to low quality gas. A local person experienced in gas fittings should be consulted to make sure the fittings, hose and burners are all compatible with high pressure gas. Heating time can sometimes be shortened and fuel use lowered by protecting the flame from breezes with a metal skirt. This is especially true if heating is being done in a partially open workshop. It is important to make sure the flame is well distributed over the bottom of the pot, not concentrated in one small circle. Raising
or lowering the pot relative to the flame can insure that the maximum heat is reaching the
cookpot. If the gas flame is yellow the air intake setting needs to be adjusted for more
efficient burning.

Wood fires frequently burn at too low a temperature for good coagulation of leaf juice. If
you are using wood fires and the juice is taking a long time to come to a boil or the curd is
very soft and fine textured, the flame may not be hot enough. The heat of wood fires can
often be increased by:
- using drier wood
- splitting the wood into smaller pieces
- increasing the air flow through the combustion area. This can be done by
  enlarging the air opening or by using a small fan to bring air to the fire.

Whenever the heating of the leaf juice is done inside it is important that the room be well
ventilated. Smoke and carbon monoxide can build up from burning in an enclosed area.
Wood stoves need to have a vent pipe or chimney of some type to draw the smoke out of
the room.

Two other techniques have been employed in heating leaf juice. These are steam injection
and trickling the leaf juice into water held near the boiling point. Steam injection is used
on larger scale operations such as the France Lucerne plant that handles many tons of
alfalfa per hour. It is probably not worthwhile on village scale operations. Trickling juice
into a pot of water has been advocated by some workers for small scale leaf concentrate
production.

The idea is to trickle leaf juice in at a rate that will never lower the water temperature
below 80° C. A curd forms almost immediately and floats to the surface. It can then be floated
down an overflow into a container below. The advantages of this system over heating in a
pot are that it is continuous and that the curd never burns because it doesn't stay in contact
with the bottom of the pan. The drawbacks are that it is more difficult to arrange and
coordinate and that the juice is not heated as conclusively to the boiling point, thus
pasteurization is not as thorough.

Curd can be obtained from leaf juice without using heat in a number of ways. These
include centrifuging, ultra-filtration, fermentation, and acidification. None of these
techniques appears to be superior to heat except in specific laboratory circumstances. In village leaf concentrate program heat is clearly the preferred way to coagulate leaf juice.

7. **Separate the curd that forms in the heated juice in a tightly woven cloth.**

After the leaf juice reaches the boiling point it should be removed from the heat and allowed to stand for a few minutes to cool. Leaving the curd a few minutes in the hot liquid assures better pasteurization with no further fuel costs. Letting the liquid cool a bit before separating the curd reduces the chances of workers being scalded from hot liquid. The cook pot should never be filled completely, especially if it is going to be moved while there is hot liquid in it. If the quantity of juice heated at one time is fairly small (under 20 liters) it can be handled by two workers pouring the entire contents of the cook pot through a filter cloth of tergel type material. This cloth can be supported by a 60 X 60 cm (2' X 2') wooden frame that has 62mm (1/4") woven wire mesh (hardware cloth) fixed to its bottom side. This can be identical to, and serve as a backup for the tray used in the hydraulic jack press. This frame can be set on a washtub so that the "whey" will pass through the cloth and be collected in the tub. The relatively large surface area and open weave of the cloth will allow the "whey" to drain freely from the curd. The curd is then placed in a more tightly woven cloth, like the cotton-polyester twill below, and pressed to remove as much "whey" as possible.

If more than 20 liters of leaf juice is being heated at a time it will be necessary to use a custom built cookpot with a valve that can allow the "whey" to be drained off after the curd is scooped out.

It has been easier for us to use rectangular than round pots for larger quantities of liquid.

A rectangular scoop similar to those used for removing foods from deep fryer can be used to remove the curd. It should be covered with a metal screening material about as finely woven as normal insect screen. The scoop can be made to barely fit inside the narrow dimension of the cookpot, so that almost all the curd can be removed by dragging the scoop the length of the pot then raising it. You may want two handles rather than one for easier handling. You can arrange for the scoop to drain for a few minutes above the cookpot after the curd has been removed. This type of arrangement is common for draining grease from deep fried foods. The valve for this type of a cookpot must be at least one inch in diameter and easy to clean. The curd from the scoop can be then put into the twill type cloth for thorough pressing.

By far the easiest way we have found to press the "whey" from the curd is to spread it in a layer not more than 2.5 cm (1") deep on the twill cloth and press it in the hydraulic press table. The process is the same as the pressing of the juice from the fiber except that twill is used instead of tergel cloth and the pressure must be applied a bit slower and held for a bit longer. After being pressed the curd should be crumbly and contain about 60% moisture.
8. What remains in the cloth is LEAF CONCENTRATE

Filter Cloth

Pressing the juice from the pulped leaves and pressing the "whey" from the curd require a mesh or filter of some type to keep the solids on one side and allow the liquids to pass through. We have found cloth to be the cheapest and easiest way to do this. We generally use a synthetic cloth like polyester Tergel for separating juice from leaf pulp and a finely woven cotton - polyester blend twill for separating "whey" from curd. The Tergel also works for the initial straining of curd from "whey" and for drying trays. Samples of these are below.

<table>
<thead>
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<th>Tergel</th>
<th>Twill</th>
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PRESERVING LEAF CONCENTRATE

Washing the Curd

Washing leaf concentrate is sometimes recommended as a means of reducing strong flavors and slowing down the growth of molds. Often a strong unpleasant flavor in leaf curd is due to soluble compounds that have not been adequately pressed out. To wash fresh LC it should well mixed in ten times its volume of clean water. It is next stirred well and allowed to stand for 10-15 minutes. It is then separated and pressed in exactly the same way as it was when the curd was separated from the heated leaf juice. The stability of the curd may be improved by adding 5% salt to the water used to wash the curd or by adding enough acid to lower the water pH to around 4. Washing adds an additional step
in the process, plus the expense of salt or acid if they are used. It also can reduce the B vitamins that are available in the curd. Where strong flavors are not a problem and the leaf curd is used or preserved soon after being made, this step is usually not recommended. If you are having trouble with strong flavored curd or rapid molding, try washing the curd.

**Why Preserve Curd?**

There are numerous reasons for wanting to preserve leaf concentrate. In most locations production of leaf crop is greater at some times of the year than others. In the tropics there is often a wet season with good leaf production and a dry season with poor leaf growth. In cooler climates there is frequently a season when cold weather severely limits leaf growth. Preserving leaf concentrate from the periods of maximum growth allows you to continue with child feeding programs or sales of products throughout the off season. Sometimes you may want to use preserved leaf concentrate when repairs are being made on machinery, changes being made at the workshop, or workers unable to work for whatever reason. Having some preserved leaf concentrate on hand is good insurance against such short term problems as running out of gas or the electric being out for a couple of days. If your program can continue to deliver leaf concentrate despite these inevitable problems, people who may have been suspicious of the program's value, will often come to respect your dependability. Where several small nutrition intervention programs are linked, it may make economic sense to produce all the concentrate at the site with the best conditions and to distribute preserved LC from there to the other sites. This will often mean lower costs for feeding programs than running several very small LC production sites using fresh leaf curd.

**How To Preserve Leaf Curd**

Fortunately, there are easy ways to preserve leaf concentrate. A few basic principles apply to all of these methods. The leaf concentrate should be preserved as soon as possible after it is made because bacterial action will begin quickly. Remember that the rich nutrient content that makes leaf concentrate so beneficial for humans also promotes rapid growth of many micro-organisms. Leaf concentrate should be stored in a container that is as airtight as possible, and it should always be stored in a location that is cool, dry, and out of direct sunlight.

A system of marking the dates that the leaf concentrate was preserved will help you to rotate your stock. This way you will use older leaf concentrate first and avoid having some go to waste because it is stored for too long. How long it can be stored is not an exact science. It will depend on the methods used and the percentage of moisture in the curd, as well as the condition in which it is stored.

No matter how long leaf concentrate has been stored it is a good idea to smell it and examine it closely before using it. If it smells of rotted vegetation or has any visible signs of mold on it don't use it.
Below are some easy formulas for preserving leaf concentrate that are possible without expensive equipment. For each kilogram of fresh leaf concentrate (at 60% moisture) you wish to preserve, mix with:

**2 kg sugar + 1 liter lemon juice**

(blend leaf curd and juice together at high speed then add sugar to make a lemonade syrup that will keep)

*OR*

**2 kg sugar + 1 liter water + 40 grams salt**

(salt helps preserve LC and reduces settling when syrup is mixed with water)

*OR*

**2 kg sugar + 1 liter water + 40 grams salt + 1600 mg vitamin C**

(This is a syrup formula we've used successfully in Nicaragua. Vitamin C, or ascorbic acid, is an antioxidant that helps preserve LC; it also makes the iron in LC easier for the body to utilize. This will provide about 25 mg vitamin C per 15 grams of LC)

*OR*

**2 kg sugar**

(to make a paste that can be added to many sweet foods and drinks.)

*The rule of thumb:* for each kg of water you need 3 kgs of sugar. So 1 kg of LC at 60% moisture contains 600 grams of water and needs to have 1800 grams of sugar added to preserve it

*OR*

**200 grams salt**

(This can be mixed and stored in airtight plastic bag, or layered and store in brine like sauerkraut. The salt needs to be washed off before it is eaten). It is important to note...
that while salt can be a fairly easy and inexpensive means of preserving leaf concentrate, that much of the beta-carotene can be destroyed if the mixture of LC and salt is exposed to air for any length of time. The very thin polyethylene bags available in many developing countries are generally not an adequate barrier for keeping out air. Heavier plastic bags (1.75 mil and thicker) will work better but are much more expensive, and not widely available. The beta-carotene is important because it is converted to vitamin A in the body.

OR

50 grams pure acetic or propionic acid

(these are harder to find and handle and usually more expensive)

OR

2-4 kg wheat, corn, millet or rice flour

(then dry to less than 10% moisture)

OR

Leaf concentrate can be dried alone

Drying LC has been a discouraging business and we have not encouraged some projects to work in that direction. In much of the tropics peak leaf yields coincide with very wet weather which makes drying in outdoor trays very difficult. Drying leaf concentrate can be tricky. The drawbacks of drying are that it tends to case harden, so there are particles of leaf concentrate that are very dry on the outside but still moist on the inside. These appear to be dry but can gradually wick moisture to the surface and mold in storage. Dried leaf concentrate can be a difficult food to work into recipes. It is often like adding sand into foods. If it is dried at too high a temperature the protein quality can be damaged. If it is dried too slowly, there is more chance of bacterial contamination or mold. It can turn an unappealing greenish black color when dried, and a grassy flavor can become stronger.

On the positive side, it is possible to make a good quality dried leaf concentrate with an inexpensive drying setup and a little extra care. There are a few things that make successful drying of leaf concentrate much easier. The most important is starting with very well pressed curd. Leaf curd that is well pressed in a closely woven cloth should be crumbly. If you can take a pinch of leaf concentrate and smear it on the palm of your hand like finger paint it is not well enough pressed. It should roll up and leave your hand clean. Well pressed curd will dry more quickly with less case hardening than wetter curd.
Granulating the Pressed Curd

One of the important factors in drying LC is how finely broken up it is beforehand. We had some problem with case hardening and mold in Nicaragua. We were just crumbling up the curd in our hands and some of the particles were larger than others. Granulating the LC by pushing it through an insect screen gives a uniform finely divided curd that grinds up easily when dried. The screen needs to be backed by hardware cloth or some kind of stronger wire mesh or the screen will pull loose from rubbing the curd through it. It is a fairly time consuming process that would need to be modified for 10-25 kg per day LC production. Pushing the curd through 1/4" hardware cloth is very fast but leaves pieces of curd large enough for case hardening.

Passing the curd into a 5 gallon blender twice for a few seconds each time, breaks most of the curd up as finely as granulating, but a few bigger pieces need to be sifted out and re-blended. Workers at the University of Wisconsin reported better drying rates when the curd is driven through 3/16" holes in a dieplate on a meat grinder before drying. We have not tried this technique yet. It may be useful when drying curd that is quite moist (70% moisture) or when more than a thin layer is put on a tray or rack.

We tried granulating the curd with the macerator as well. It required two passes and we needed a plastic skirt to prevent the granulated curd from bouncing and blowing out of the washtub below the macerator. It was dramatically faster and easier than the manual granulator. The curd needs to be well pressed for this to work. In Mexico, we are recommending that the curd from the previous day be granulated in the macerator first thing in the morning when the machine is clean and dry, and then the maximum sunshine would be available for drying during the day.

There are many different types of food dryers that could be used to dry leaf concentrate. Described below are the simplest, least expensive ones that we've had success with in Mexico and Nicaragua. Some other types of food dryers are described in the chapter on "Other Leaf Concentrate Processing Equipment".

Tray or Rack Dryers

We have been using large trays or racks covered with finely woven synthetic fiber for drying LC in a few locations. Cloth such as nylon curtain material that is open enough to allow the passage of air is ideal for making drying racks. The dried curd comes off synthetic cloth more cleanly than it does from cotton. This cloth can be stretched tightly over wooden frames. The corners of the frames should be braced to maintain rigidity. The leaf concentrate is spread in a thin even layer on the frames at a rate of one to two kilograms per square meter (1/4 - 1/2 pound per square foot). Trays of under 1 meter (39 X 39") on each side can be loaded, moved and emptied fairly easily by a single person. Our larger trays 180 X 85 cm (72 X 34") were difficult to handle. The worst trays were
this size with a cross brace across the middle that made them almost impossible to empty without spilling some of the dried LC.

**Simple Solar**

The simplest way to use these racks is to put them outside where the sun shines all day. They can be set up on bricks or blocks to allow the free movement of air underneath. It is essential that the racks be covered in such a way that the heat from the sun reaches the drying curd but the light from the sun does not. Direct sunlight will quickly destroy the beta-carotene (pro-vitamin A) in leaf concentrate. It is possible to stack drying racks on top of each other in such a way that each provides shading for rack below. Then only the top rack needs a cover. Of course, this gives the trays less exposure to the sun's heat than if they are spread out only one tray deep. Tightly woven black cotton cloth works well for blocking the ultraviolet rays while absorbing the solar heat.

A somewhat more expensive dryer can be built in place. A light wooden frame box roughly 2 meters X 2 meters (c. 78 X 78") is inclined from c. 50 cm to 20 cm (20 to 8”) to shed water. It is covered with 4 mil clear polyethylene supported with wire poultry netting. Trays with granulated leaf concentrate spread at approximately 2 kg per m² (c. ½ lb per square foot) were slid into frames about 10 cm (4") below the polyethylene. The same trays were used but they were covered with black cotton cloth to protect the leaf curd from sunlight. The sides had removable sheet metal panels that allowed the trays to be slid in or out. It was not airtight and the only airflow was what came through small incidental openings in the box.

This was a very effective dryer. It quickly reached temperatures of 50 -55°C. In a comparison test we dried 2 kg per meter ² granulated LC (64% moisture) for 2½ hours at 28°C air temperature on each of the dryers. On this dryer the LC was 13% moisture after 2½ hours. Ultraviolet resistant polyethylene film would be good as the more common film that we used photodegrades in less than one year. UV resistant film would probably have to be imported.

We used the same principle of letting the sun pass through the clear plastic film to heat up black cotton cloth stretched over the curd, but in a much simpler and cheaper arrangement. Plastic film was attached to one side of a wooden frame 180 X 85 cm (72 X 34") and black cloth stretched across the other side. This frame was simply placed over a drying tray (which was made with fine weave tergel polyester cloth) loaded with granulated LC and supported by bricks at the corners. After 2½ hours the LC was 21% moisture. It heated up to 40 - 45°. The airflow below the drying tray was significantly greater than in the box and may have been partly responsible for the lower temperatures and slower drying. These frames are simple, cheap, and mobile, and stackable.

**Grinding and Storing Dried Leaf Concentrate**
For leaf concentrate to store well it should be dried to less than 10% moisture then sealed in an airtight container out of sunlight. Thin plastic bags will allow too much oxygen to pass through to the dried curd. Without a moisture meter it is somewhat difficult to tell if your concentrate is dry enough. You can do a rough moisture test on a small amount by putting 100 grams of the air dried concentrate in a very low oven (100° C [220° F]) for 12 hours and weighing the difference. For rough tests I dry a sample until it seems to be very dry then weigh it. Then I dry it for another 15 minutes and put it back on the balance. If there is no measurable difference in weight, this can be considered to be the dry weight. You will need a fairly accurate gram balance to do this.

The dried leaf concentrate is far easier to use later if you can grind it to a very fine powder. It will have a lighter green color and incorporate much better in recipes if it is ground nearly as fine as flour. Dried LC that is not ground very finely will leaves foods with an unpleasant gritty texture. The high protein content of LC makes for very hard particles when it is dried. If dried LC is not ground very finely some of it may pass through the body as particles without being fully digested and absorbed. So fine grinding will also make it easier for the body to utilize the nutrients in dried leaf concentrate.

You may need to sift it through a fine cloth to make sure it is all finely ground. We have found that it is difficult to grind dried LC finely enough with the inexpensive hand operated flour mills available in many developing countries. Commercial grinders are reluctant to grind LC because some of it will remain in the mill and give flour a greenish hue for a while. The most effective tool I have found for grinding dried LC is an electric mill with stainless steel heads made in the US. It is called MagicMill and retails for about $240 US. Their address is in the resource section in the rear of this manual. Be sure to specify whether you want a 60 HZ (US and Central America) or 50 HZ (most of the rest of the world) motor. They are very loud and quite slow. These mills will grind a kilogram of dried LC in about 20 minutes. However you grind dried LC, try to avoid breathing the fine green dust that is made in the process. Putting the grinder inside a plastic washtub with a wooden top and a cloth airvent made the grinder far quieter and eliminated the dust problem. We are still looking for a better solution to the problem of grinding dried LC.

Finely ground dried LC works well in most recipes. Generally if you use one third as much dried LC as fresh and add two parts of water you have approximated the fresh LC. So that 1 kg dried LC plus 2 liters water is roughly equivalent to 3 kg fresh LC. Dried LC has not worked well in drink mixes. It settles too quickly even when finely ground. Most drinks are sweet enough so that sugar preservation of the fresh LC is a better option.
The Basics of Drying LC

1. Start with very well pressed curd (c. 60% moisture)

2. Granulate the curd to get small uniform sized particles and increase the ratio of surface area to weight

3. Expose the granulated curd to heat. 50°C [120°F] is ideal, 60°C [140°F] is the maximum

4. Expose the granulated curd to moving air to remove the moisture that evaporates from the surface of the LC

5. Dry the LC as quickly as possible after it is made

6. Protect the drying LC from sunlight, blowing dust, insects, and rodents

7. Dry to below 10% moisture. If you're not sure, finish drying it in an oven at a very low temperature

8. Grind as finely as possible

9. Store in thick, well sealed plastic bags, with as much air removed as possible; in a cool dark place

SECTION II
NUTRITION

People whose diet provides their body with a regular and adequate supply of the 40 nutrients essential for growth and health are said to be well-nourished. Those whose diets fall short on one or more of these essential nutrients are malnourished. Malnutrition is the biggest health problem in the world. The World Health Organization estimates that 730,000,000 children in the world are currently malnourished. In Mexico it is estimated that 1 child in 3 is malnourished.

Malnourished children are smaller and weaker than their peers. They have more frequent and more severe intestinal and respiratory infections, and they take longer to recover from them. Their attention span is shorter and their ability to concentrate or remember things is less than that of well nourished children. Their life expectancy is shorter. In severe cases, they suffer permanent mental and physical damage in their first tender years of life from a lack of enough food. In a world where the struggle to succeed can be very tough, they begin life at a tremendous disadvantage, through no fault of their own.

The suffering and loss of human potential from malnutrition is unnecessary. Malnutrition is preventable in much the same way that smallpox and polio are. While there is no vaccine against malnutrition, the same creative forces that developed the vaccines and the same determination that makes sure children are vaccinated against crippling diseases can free our children from the plague of malnutrition. Leaf concentrate can be a powerful tool in the effort to defeat malnutrition.

While a lack of any one of 40 essential nutrients can cause a specific deficiency disease, malnutrition almost always involves an under supply of many nutrients, chief among them:

- protein
- energy or calories
- iron
- vitamin A
- calcium
- iodine
- folic acid
- vitamin E

Let's take a closer look at these nutrients and the role they play in the human body, and at what foods supply them best.

PROTEIN:
Proteins are the basic building blocks of life. They are needed daily to build and repair muscles, maintain healthy brain cells, and for a wide range of enzymes and hormones that are involved in everything from digestion to sexual response and emotions. Proteins are especially important to young children and pregnant and lactating mothers. Children under 14 months can suffer permanent mental retardation from an inadequate supply of protein. Proteins are also very important when recovering from an illness or injury. Other nutrients, especially vitamin A, will not be fully utilized if the diet doesn't have sufficient protein.

Below several common foods are grouped by how much protein they contain.

<table>
<thead>
<tr>
<th>Highest</th>
<th>High</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
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</thead>
<tbody>
<tr>
<td>Soy</td>
<td>Leaf</td>
<td>Beans</td>
<td>Wheat</td>
<td>Cassava</td>
</tr>
<tr>
<td>Concentrate</td>
<td>Chicken</td>
<td>Milk</td>
<td>Corn</td>
<td>Plantains</td>
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<td></td>
<td>Fish</td>
<td>Rice</td>
<td>Millet</td>
<td>Potatoes</td>
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<td></td>
<td>Pork</td>
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<td>Sweet</td>
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<tr>
<td></td>
<td>Beef</td>
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<td>Potatoes</td>
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<tr>
<td></td>
<td>Cheese</td>
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<td>Yams</td>
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<td></td>
<td>Eggs</td>
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<td>Taro</td>
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<td></td>
<td>Fruit</td>
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</tbody>
</table>

Not only is the amount of protein important to us, but also the quality of that protein. The form of protein in some foods like milk and eggs is in a form that is more useful to us than the protein in corn or beans. This means we need to eat more grams of protein from corn or beans to have the same benefit to the body as the protein from milk or eggs.

Below several common foods are grouped according to the quality of their protein.

<table>
<thead>
<tr>
<th>Highest</th>
<th>High</th>
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<td></td>
<td></td>
<td>Fruit</td>
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</table>
Generally speaking the protein from animal sources, i.e., meat, milk, or eggs, is of higher quality than the protein from plants, i.e., beans, grains, or vegetables. One can improve the quality of protein from plants by mixing them. For example, the traditional Mexican mixture of corn and beans has a higher quality protein than either corn or beans alone. The same is true with the traditional Indian meal of chapatis (wheat) and dahl (beans), or the Chinese rice and soy beans, or the African millet and cowpeas. The protein in leaf concentrate is an excellent complement to the protein found in corn, wheat, rice, or millet.

Many people think that it is necessary to eat meat to receive an adequate supply of protein. This is not true, as many studies of vegetarians have shown. People who eat very little meat or other animal products like milk, eggs, or cheese, need to eat more grams of protein and remember to mix them. Because meat ordinarily takes more land to produce than grains or beans or vegetables, meat price will continue to be too high for meat to play a major role in the diet of billions of people. Because of this it is very important that we learn more about using vegetable proteins wisely.

Diets that are extremely rich in protein, especially protein from meat, have been strongly linked to osteoporosis, a disease in which the bones becomes brittle from losing calcium through the urine. Osteoporosis is prevalent among post-menapausal women, as the female hormone estrogen which protects the body's calcium is no longer produced in sufficient quantity. Excessive protein in the diet is rarely a problem among low income groups in the developing world, as most protein sources are much more expensive than foods rich in carbohydrates.

**ENERGY:**

Calories are a way to measure the energy in foods that power all human activity. Starches and sugars are the most important sources of energy, followed by fats and oils, then by alcohol. Carbohydrates and proteins have an energy value of about 4 Calories per gram, while fats have about 9 Calories per gram. Fats are said to be denser in energy. Sometimes weaning foods and foods for young children are too bulky for the energy that they provide the child. A child will become full before he has eaten enough to meet his energy needs.
Water and fiber take up room in a child's stomach but do not supply energy. Sometimes traditional coarse porridges will have too much water and fiber to be adequate weaning foods.

The energy density of these foods can be improved by adding a small amount of oil or fat. Vegetable oils are generally considered to be better for us than lard or other animal fats like butter. These animal fats contain a lot of saturated fats and cholesterol, which have been tied to hardening of the arteries and heart disease. Coconut oil is also sometimes avoided because it is chemically more like animal fats than oils pressed from soy, sesame, safflower, cotton seed, rape seed (canola) and olives. Palm oil, although rich in saturated fat has been found to act more like vegetable oils that are rich in mono-unsaturated fats, such as soy and cottonseed oil. There is more information on porridges as weaning foods in the recipe section of this manual.

Complex carbohydrates like corn, wheat, beans, potatoes or fruit are considered to be healthier than refined sugar as energy sources for people. This is because they contain a range of other nutrients and they burn more slowly, which delivers energy to the body at a more consistent rate. Foods high in refined sugars, for example soft drinks, are sometimes said to contain “empty Calories”. In some parts of the developing world, like urban Mexico, refined carbohydrates are making up a rapidly growing percentage of the Calorie intake. When this happens a person will meet his Calorie requirement long before reaching recommended intakes for several other nutrients. He must then either overconsume Calories to meet his other needs and become obese, or become deficient in one or more essential nutrients.

A child who is not getting enough Calories in his diet will typically sit quietly and be apathetic while other children play. His body is trying to conserve the limited supply of fuel for more essential activities like breathing and pumping blood. A child who is not getting enough Calories from carbohydrates, fats and oils will burn up valuable proteins for fuel. Fresh leaf concentrate has about the same number of calories as an equal weight of chicken or eggs, but because it is usually eaten in rather small portions, it is not an important source of Calories.

**IRON:**

Iron deficiency anemia is the most common nutritional disease in the world. Especially at risk are women of childbearing age, who need extra iron for menstruation, pregnancies, and lactation; and young children, who need extra iron for rapid growth. UNICEF estimates 50% of the children in developing countries (c.500 million children) and 60% of the pregnant women in these countries suffer from iron deficiency anemia. The World Health Organization considers young children with hemoglobin counts below 11.0 g/dl or older children and adults with values below 12.0 g/dl to be anemic. Whenever blood is
lost, as with wounds, hookworm, malaria, internal bleeding as with ulcers, menstruation or childbirth, iron needs go up significantly.

The body needs iron to make hemoglobin, which enables our blood to carry oxygen to every part of our bodies. When the supply of iron is low we can't carry enough oxygen to our cells to burn the fuel efficiently. When this happens we feel tired. Anemic children are smaller and grow more slowly than those with normal hemoglobin levels. They have less energy for playing or learning. Their mental development may be retarded and their attention span reduced. Their immune response is depressed, which leaves them more vulnerable to infections.

When women are anemic during their pregnancies, as the majority in developing countries are, their babies are more likely to be born prematurely or underweight. A woman whose diet is marginal in iron intake who has children closely spaced will often suffer from severe anemia. This can make her lethargic and apathetic and less able to care for her children. These babies are born with low iron stores in their livers and often become very anemic themselves before they are old enough to absorb adequate iron from the food they eat. These families have a high risk of severe health problems and should be a top priority in leaf concentrate programs.

As with protein, we must consider both the quantity and the quality of iron in the diet. Much the same as protein, animal based foods tend to be richer in both the quantity and quality of iron than plant based foods. However, as is the case with protein, it is very possible to get an excellent supply of iron from plant sources if one has a little information on the subject. Almost all diets contain more iron than the body needs. The problem is that most of the iron is poorly absorbed. Some of the iron in meat, fish, and poultry (heme iron) is quite well utilized, but the iron in grains, beans, and vegetables, and the remaining iron in animal based foods (non-heme iron) is very poorly absorbed. Because meat production yields less food per hectare than grains, beans, and vegetables; meat products are usually too expensive for poor families in developing countries to buy. As a result the women and young families in these families suffer from very high rates of iron deficiency.

A chart in the appendix summarizes a study of anemic children in Bolivia that were given six grams of dried leaf concentrate five days a week for five months. The leaf concentrate costs about 5 cents per serving or about 5 dollars per child for the entire time. The leaf concentrate is especially effective when combined with a source of vitamin C, such as citrus fruit.

Anemia in adults lowers productivity and capacity to do work. This, of course, affects their ability to earn an adequate income and increases the likelihood that their children will be malnourished. Increasingly we see that anemia is implicated in a vicious cycle of malnutrition and poverty. Reversing anemia is a sound investment. A study in Indonesia, reported in the American Journal of Clinical Nutrition, showed than an iron supplement to
anemic workers improved productivity an average of 15-25%. This meant a return of $260 for each $1 spent on the supplements.

Below are some common foods grouped by iron content.

<table>
<thead>
<tr>
<th>Highest</th>
<th>High</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Concentrate</td>
<td>Beef</td>
<td>Fish</td>
<td>Corn</td>
<td>Rice</td>
</tr>
<tr>
<td>Liver</td>
<td>Pork</td>
<td>Chicken</td>
<td>Mangoes</td>
<td>Milk</td>
</tr>
<tr>
<td>Eggs</td>
<td></td>
<td>Greens</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beans</td>
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<td></td>
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</tbody>
</table>

* Please note that milk, while an animal product, contains almost no iron.

In some areas certain products are enriched with iron. Flour, bread, macaroni, and baby formulas are often fortified with iron. Find out if any common foods are fortified where you live and if these products are regularly eaten by low income families.

The absorption of non-heme (plant) iron is even worse when a meal contains a lot of bran, the fibrous part of grains. Tannin, which is found in tea, also makes non-heme iron more difficult to absorb. Deficiencies of other nutrients can aggravate anemia. Most important of these are:

- Folic Acid
- Protein
- Vitamin A
- Vitamin B-6
- Riboflavin
- Copper

The presence of meat in a meal makes the non-heme iron much more usable; but as was pointed out earlier meat is usually too expensive to be eaten by the poor. Ascorbic acid or Vitamin C also makes non-heme iron more useful to the human body. The study from Bolivia shows this relationship. Basically, the absorption of non-heme iron is considered to be four times as great in a diet containing 90 grams of meat or 75 mg of Vitamin C, as in a diet with less than 30 grams of meat or 25 mg of Vitamin C.

This is a very important consideration. It is often easier, cheaper, and more effective to add vitamin C, than to add more iron to the diet. Roughly speaking, a woman consuming over 75 mg of vitamin C will need only 1/4 as much iron as a woman consuming less than 30 mg of vitamin C; if the iron is from non-animal sources. Unfortunately the vitamin C in
leaf juice is destroyed when it is heated, so leaf concentrate contains very little of this vitamin. We can compensate for this, however, by adding lemon juice or other sources of vitamin C. Leaf concentrate lemonade is therefore an extremely useful food for women and children suffering from anemia. Other good sources of vitamin C are guavas, other citrus fruits, fresh tomatoes, dark green vegetables, and other fruits and fruit juices.

Vitamin C Content of some Tropical Fruits

<table>
<thead>
<tr>
<th>Fruit</th>
<th>mgs. Vitamin C per 100 grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acerola</td>
<td>1,677</td>
</tr>
<tr>
<td>Guava</td>
<td>183</td>
</tr>
<tr>
<td>Orange Peel</td>
<td>136</td>
</tr>
<tr>
<td>Lemon Peel</td>
<td>129</td>
</tr>
<tr>
<td>Kiwi</td>
<td>98</td>
</tr>
<tr>
<td>Longans</td>
<td>81</td>
</tr>
<tr>
<td>Lemon (whole with peel)</td>
<td>77</td>
</tr>
<tr>
<td>Jujube</td>
<td>69</td>
</tr>
<tr>
<td>Papaya</td>
<td>61</td>
</tr>
<tr>
<td>Pummelo</td>
<td>61</td>
</tr>
<tr>
<td>Strawberry</td>
<td>56</td>
</tr>
<tr>
<td>Orange</td>
<td>53</td>
</tr>
<tr>
<td>Lemon (without peel)</td>
<td>53</td>
</tr>
<tr>
<td>Cantaloup</td>
<td>42</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>38</td>
</tr>
<tr>
<td>Kumquats</td>
<td>37</td>
</tr>
<tr>
<td>Mulberries</td>
<td>36</td>
</tr>
<tr>
<td>Tangarine</td>
<td>30</td>
</tr>
<tr>
<td>Passionfruit</td>
<td>30</td>
</tr>
<tr>
<td>Mangos*</td>
<td>27</td>
</tr>
<tr>
<td>Starfruit (Carambola)</td>
<td>21</td>
</tr>
<tr>
<td>Pineapple</td>
<td>15</td>
</tr>
<tr>
<td>Sapodillar (Manilkar zapota)</td>
<td>15</td>
</tr>
<tr>
<td>Prickly pear (Opuntia spp.)</td>
<td>14</td>
</tr>
<tr>
<td>Apricots</td>
<td>10</td>
</tr>
<tr>
<td>Grapes</td>
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</tr>
<tr>
<td>Watermelon</td>
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<tr>
<td>Cooked Plaintains</td>
<td>10</td>
</tr>
<tr>
<td>Bananas</td>
<td>9</td>
</tr>
<tr>
<td>Tamarinds</td>
<td>4</td>
</tr>
</tbody>
</table>

* Mangoes are considerably richer in vitamin C when slightly unripe.
Some vegetables are also good sources of vitamin C. For example, 100 grams of fresh kale contains about as much vitamin C as an equal weight of guavas. Part of the vitamin C is lost when vegetables are cooked. A study of leafy vegetables in Sri Lanka showed that on average the vegetables lost 32% of their vitamin C in five minutes of boiling and 54% in ten minutes. Steaming resulted in losses of 15% in five minutes and 39% in ten.

Small amounts of meat, especially organ meats, also help the body to absorb iron from non-animal sources. To be effective the vitamin C or meat must be eaten in the same meal as the iron source. The small amount of iron that enters our food from steel or iron food processing equipment is generally beneficial. A small amount of rust from iron cook pots may also be somewhat beneficial where iron deficiency anemia is prevalent.

Recent studies from Scandinavia have indicated that high levels of iron, especially in adult men may be a factor in heart disease. Men who are heavy meat eaters are more likely to be at risk. These studies will need further confirmation before they are used for general dietary recommendations.

VITAMIN A:

Vitamin A is essential for good vision and for the body's protection against disease organisms. People with low vitamin A intakes are more susceptible to several forms of cancer. Vitamin A is essential to the health of the mucous membranes that line the digestive and respiratory systems. This is the body's first line of defense against infection. Studies in Indonesia have shown children with low levels of vitamin A to be about 4 times as likely to suffer from diarrhea and respiratory infections as are children with adequate vitamin A levels.

The classic symptom of serious vitamin A deficiency is night blindness. Any children that have trouble seeing toys at dusk are probably somewhat deficient in vitamin A, and should receive immediate vitamin A in some form. About 500,000 children under 5 years of age go permanently blind from vitamin A deficiency in the world each year. Most of these children die from infections within a few years of going blind. Leaf concentrate, even in very small amounts, is extremely effective in combating vitamin A deficiency.

Actually, the vitamin A from plant sources is in the form of beta-carotene, which is converted in our bodies to vitamin A. Vitamin A is stored in our livers so we don't need to eat it every day. Food scientists have come to believe that the amount of vitamin A the human body requires for optimum health is much greater than it was previously thought to be. The new US Recommended Dietary Allowances have thus been greatly increased. Leaf concentrate is so rich in beta-carotene that only 10 grams will meet the new higher USRDA for vitamin A in a 4-6 year old child.
Some foods are grouped below according to their content of vitamin A.

<table>
<thead>
<tr>
<th>Highest</th>
<th>High</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Concentrate</td>
<td>Dark Green Vegetables</td>
<td>Winter Squash</td>
<td>Meat</td>
<td>Rice</td>
</tr>
<tr>
<td>Liver</td>
<td>Carrots</td>
<td>Eggs</td>
<td>Fish</td>
<td>Milk*</td>
</tr>
<tr>
<td>Mangoes</td>
<td></td>
<td>Papaya</td>
<td></td>
<td>Potatoes</td>
</tr>
</tbody>
</table>

* In some areas milk is fortified with Vitamin A.

CALCIUM:

Calcium is needed for strong bones and teeth. Low levels of calcium in the diet can lead to brittle, poorly formed bones and easily decayed teeth. Calcium is very important in the diets of older women, who often suffer from osteoporosis, or brittle bones. Osteoporosis can determine whether a slip and fall causes a few bruises or crippling broken bones and long periods of immobility.

Several foods are grouped below as sources of calcium.

<table>
<thead>
<tr>
<th>Highest</th>
<th>High</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Concentrate</td>
<td>Dark Green Vegetables</td>
<td>Tortillas*</td>
<td>Rice</td>
</tr>
<tr>
<td>Cheese</td>
<td>Sesame Seeds</td>
<td>Beans</td>
<td>Corn</td>
</tr>
<tr>
<td></td>
<td>Milk**</td>
<td>Meat</td>
<td>Fruit</td>
</tr>
</tbody>
</table>

* In Mexico and some parts of Central America corn tortillas and other corn products make up a very large part of the peoples' diet. Traditionally, the corn is prepared by first soaking it overnight in lime water. This process, called Nixtamalization, adds substantial quantities of calcium to the diet.
The majority of the adults in the world are lactose intolerant. This means they are not able to digest lactose, the sugar in milk. There is more on this subject in the "Discussion Topics" chapter.

IODINE

Iodine and folic acid are two other essential nutrients that are frequently deficient in the diets of low income people in developing countries. Iodine is needed to help us regulate our metabolism, that is, how fast our engine runs and how quickly we burn up fuel. It is abundant in fish, seafood, and seaweed. Whether plants contain adequate iodine depends very much on how much iodine is in the soil. Many regions have soils that are depleted in iodine. In these regions iodized salt, if available, is good protection against this deficiency.

Plants from the cabbage family, including kale, collards, broccoli, and turnip greens contain goitrogens, or substances that block the absorption of iodine. These are deactivated by cooking. Cows that are fed large quantities of forage kale can pass the goitrens on in their milk, and children drinking this milk can become iodine deficient.

FOLIC ACID

Folic acid, sometimes referred to as folacin, helps us to use iron. It is often in short supply in anemic people. Fresh green vegetables and wheat germ are excellent sources of folic acid. Whole grains and leaf concentrate are good sources. Folic acid is sometimes prescribed for pregnant women, as they are especially prone to the deficiency. Some caution should be exercised in using folic acid supplements, however, because high levels of folic acid can mask the symptoms of pernicious anemia, which is an inability to absorb or utilize vitamin B-12 or cyanocobalamin. This is a fairly rare disorder.

VITAMIN E

Vitamin E is an antioxidant that protects the body from lipid peroxidation, an oxygen reaction that turns cholesterol into more toxic forms implicated in hardening of the arteries. It has also been shown to offer protection against some forms of cancer and to improve general functioning of the immune system. The exact mechanisms by which vitamin E works are not yet fully understood, but there is widespread agreement among nutritional scientists that it is far more important to maintaining good health than was previously thought.

Six grams of dried LC provides about 20% of the USRDA (United States Recommended Daily Allowance) of vitamin E. Sunflower seeds, nuts, wheat germ, and vegetable oils,
such as soy, corn, and safflower are other excellent sources of vitamin E. This vitamin does not occur in animal products.

SECTION III

AGRICULTURE

A successful leaf concentrate program will usually have three components of roughly equal importance:
- producing the leaf crop
- processing the crop into leaf concentrate
- marketing or distributing the products

This section will address the first of these. In many projects the cost of the leaf crop represents one half of the total cost of producing leaf concentrate. It is usually the biggest single expense, and the most obvious place to look for ways to reduce production costs. Insufficient supply of fresh leaf crop in top condition is a persistent problem at most leaf concentrate projects.

WHO SHOULD GROW THE LEAF CROPS?

Often it has been assumed that local farmers would be producing forage crops that could be used by projects, and the project would be able to purchase leaf crop from a dependable local market. This has been the exception for several reasons. Even where a suitable forage crop, such as alfalfa, is commercially grown, it may not be harvested in such a way as to be available on a daily basis. In northern Mexico we have a project in an area of large irrigated alfalfa fields that yield very well. However, almost all of the crop is cut for hay. This means that 100 hectares may be available for leaf concentrate production today and it will all be mowed for hay tomorrow. In some locations where leaf concentrate could have a major benefit on malnutrition, there is no suitable forage crop currently under commercial cultivation. This is the case in Nicaragua.

In Bareilly, India farmers had several concerns that dampened their enthusiasm for growing leaf concentrate crops. Among these were the perception that the crops needed to be weeded more often than other crops; that cutting a relatively small amount of leaves each morning would ruin a small farmer's chance of securing day labor; and that unfenced animal could eat the leaf crop.

Small leaf concentrate projects will rarely purchase enough crop to entice many farmers to alter their normal growing and harvesting techniques. A project may decide the most economical and dependable way to supply adequate leaf crop is to grow it themselves. Or
it may be possible to contract with a few farmers to supply the crop. Both approaches have their pitfalls.

A group that is undertaking a leaf concentrate project will usually have its hands full with processing and distribution of the leaf concentrate. Growing leaf crops brings in a new set of work conditions and problems and may spread the project management too thinly. Agricultural experience and skills are not quickly acquired and several groups have failed miserably at producing their own leaf crops because they were not farmers by trade. Ownership of land can be very expensive and renting or leasing it may not provide much security. Agricultural equipment can also be an expensive and complicated arena for a small leaf concentrate to enter. If irrigation is being used the cost can be daunting and management of irrigation systems can be complex.

Contracting a few farmers to supply your project with fresh leaf crop can leave you completely dependent on one individual. The farmers may try to take advantage of this dependency by overcharging for leaves, or by wetting the leaves beforehand if they are sold by weight. Contracting more farmers can spread out your dependency, but it also means that you have to deal with several people. You may have to coordinate a schedule of sales among the several farmers. If you are buying 200 kg per day from one farmer, that may represent a very important source of income for him that he will protect by meeting your expectations as a buyer. On the other hand if you spread your purchase of leaf crop among 5 farmers, the sales may not be important enough to any of them to assure that you get priority treatment as a consumer.

There is no easy answer to this dilemma. Any solution will have to take into account the many specific conditions of your project and the agricultural realities in the area. A couple things that may be useful are to select a member of your group or cooperative to take primary responsibility for making sure the leaf crop arrives on time and in good condition. This person could be someone who already has agricultural experience, or you could try to recruit a person with farming skills into your group to widen your base. It may make sense to send a member to some type of agricultural training course. Both regional and foreign agricultural schools and universities often have programs to give students hands on experience by working with charitable organizations. This can be a great source of free or nearly free specialized help, but it best not to have unrealistic expectations of what students will accomplish. If you are contracting a farmer or several farmers it will probably be useful to have them observe the leaf concentrate process and the feeding of malnourished children. This will help the farmers identify with the project and to understand its importance to their community.

**CHOOSING LEAF CROPS**

Not all leaves are suitable for making leaf concentrate. There are an estimated 350,000 species of flowering plants in the world and it is unlikely that as many as 500 of them have been evaluated as possible leaf concentrate source plants. While hundreds of species of
plants have been evaluated for making leaf concentrate; in any region there are usually 2 or 3 that are the most productive or the most economical. It is important that more plants be tested. Leaf For Life and a few other groups, notably TRIADES in Hawaii, as well as several more academically oriented institutes, continue evaluating crops for their potential to make leaf concentrate. The following information should help you to understand the process of selecting crops better and to give you a sense of what has already been done.

While we'd like to avoid the dissipated energy from continually reinventing the wheel; it is worth noting that a good many improvements in wheel technology have taken place since the original invention was made. We have found on many occasions that our field test results differed from a published report on a crop, sometimes for better and sometimes for worse. If you are planning to do some testing of possible leaf concentrate crops, it is worth remembering a few things that might make your work more useful to other people working in this field. Use scientific, in addition to local names for crops. Local names like Chinese Spinach or quelite may refer to several different plants in different location. Everyone in southern India may know what Patsam or Makchari is, but it is impossible for a Latin American worker to find out without the scientific name. Use the metric system of measurement. Record as much information as possible. The age of the plants at harvest, the cultivar or variety of a plant if it is known, the method of processing, are all important if we are trying to compare the performance of different plants. The moisture content of the plant leaves and the leaf concentrate are probably the most important. Field reports of very high yields for LC without identifying the moisture content are meaningless. I've read a detailed analysis of leaf concentrate from Bolivia that was 83 % moisture. Others are as low as 55 %. There is a difference between the weight of dried LC (which is usually around 10% moisture) and the dry weight of LC (0% moisture). The chart on yields at the end of the agricultural section will give you a good idea what constitutes a good yield. It is calculated from the dry weight of the leaves to the dry weight of the LC. Both should be dried for 12-16 hours at about 100° C, to determine dry weight.

**GENERAL NOTES ABOUT SELECTING CROPS FOR LEAF CONCENTRATE PRODUCTION**

Three great divides separate potential leaf crops quickly into functional blocks:

1. Tropical vs. Temperate and Subtropical plants
2. Perennial vs. annual plants
3. Legumes vs. Non-legume plants

*Tropical* plants normally thrive in hot climates and don't tolerate frost. *Temperate* plants are adapted to areas with a cold winter and warm summer. *Subtropical plants* are best suited to the edge between the tropical and temperate zone or to higher elevations within the tropics. Most of the research that has been done on leaf concentrate has been done in temperate zones in Europe and the United States and more information is available on temperate crops as sources of leaf concentrate. Medicago sativa (alfalfa or lucerne) is a *temperate, perennial legume* that has been studied extensively and is used in commercial leaf concentrate production for animal feed. It is the benchmark crop against which leaf concentrate crops must be compared. In addition to alfalfa, temperate and subtropical leaf
concentrate candidates include clovers (especially berseem); members of the cabbage or mustard family, small grains such as wheat and oats, and chenopods, including beet greens, lambsquarters, Swiss chard, orach, and quinoa.

Many of the temperate zone candidates are commonly eaten as vegetables and have been bred for centuries to reduce the levels of toxic or bitter components. Economically, it is difficult to compete with alfalfa which can yield up to 120 tons of green matter per hectare, fixes its own nitrogen from the air, can be cut many times a year, and only needs to be replanted every 4-8 years. Some mixes of annuals, for example wheat and mustard, may give even greater yields and have milder flavored curd than alfalfa, though they would require more labor and energy inputs as well as nitrogen fertilizer.

One area of interest is by-product leaves of commercial vegetables, such as beets, cauliflower, radish, and sugar beet. A leaf concentrate operation near a packing plant could potentially improve the economics of growing these vegetables by making a high value product from leaves that are currently low value or a disposal problem.

Tropical plants must receive more of our attention for several reasons. As stated above, there are already good LC crops in the temperate zones. Even more basic is the fact that LC is much more needed in the tropics. The humid tropics have a large number of people, the fastest growing populations, the greatest prevalence of malnutrition, and the fewest technical and financial resources with which to meet the food requirements of its people of any region on earth. Compared to the temperate zones, the tropics have a longer growing season but generally more problems with insects, viruses, fungus, nematodes and noxious weeds. Tropical soils tend to be more fragile and less fertile. Soil moisture and nitrogen are lost much more quickly to the air because of the high temperatures. Generally far less systematic breeding has been done with tropical leaf crops and they often exhibit tremendous genetic differences from one variety to another.

If alfalfa is the benchmark crop for the temperate zones, I would suggest, for the time being that Vigna unguiculata (cowpeas) is the tropical plant against which all candidates be compared. Cowpeas are not as strong an LC crop as alfalfa, but they are eaten as a leaf crop in many countries, thrive in hot humid conditions, come up quickly, and produce good yields of mild flavored leaf curd. They are well suited to a variety of intercropping schemes, are capable of fixing large amounts of atmospheric nitrogen, and make a good green manure crop. The humid tropics have much greater diversity of plant life than the rest of the planet, and as a result there are thousands of plants that may have potential as leaf concentrate sources.

Although the great majority of plant species have never actually been processed for leaf concentrate, we can narrow the search very quickly by applying a set of criteria for plants we hope to use to make leaf concentrate, by looking for plants that maximize the positive characteristics given below and minimize the negative ones.

Positive Plant Characteristics in Potential Leaf Concentrate Sources
- known to be edible by humans in the area where it would be used
- palatable to animals
- consistently yields large amount of green forage (30 tons per hectare per year or more)
  - produces green forage over most of the year
  - moisture content of fresh leaves above 75% and below 90%
  - protein content in fresh leaves at least 2.5%
  - can fix atmospheric nitrogen (leguminous plants like beans, peas, clovers, alfalfa and many tropical trees have nodules on their roots that can turn the nitrogen in the air into nitrates that can be absorbed by plants)
  - can be used as a green manure or be intercropped with local commercial crops
  - erect, non-twining growth habit for ease of harvest
  - resistance to common tropical virus, insect, fungus and nematode problems
  - establishes quickly enough to compete with weeds
  - leaves will regrow after harvest for repeated cuttings
  - seed or cuttings for propagation readily obtainable
  - can withstand drought
  - can tolerate low fertility, aluminum, and acidity in soil
  - can tolerate salinity and high pH
  - has multiple purposes (i.e. edible seeds or roots, green manure, useful for industrial purposes such as medicine, paper or textile manufacture)

**Negative Plant Characteristics in Potential Leaf Concentrate Sources**

- high concentrations of toxins, especially toxic amino acids in plant leaves
- high levels of tannins or phenolic compounds that can bind with proteins and make them difficult to absorb (this can often be determined by leaf juices spontaneously coagulating at room temperature)
  - leaf juice forms bitter or unpleasant tasting curd
  - leaf juice that doesn’t coagulate readily when heated to boiling
  - mucilaginous leaf juice that is difficult to separate from fiber, A simple rule of thumb is to rub a few tender leaves from the plant in question between your fingers; the juice released should be thin and watery not thick or sticky.
  - acidic leaf juice
  - leaf juice that forms a very fine soft curd that is difficult to separate from whey
- leaves that are difficult to harvest (how long will it realistically take to harvest 200 kg of fresh leaves from this plant? This is usually a minimum daily amount for an economical production site. An experienced Mexican farm worker can cut 200 kg of alfalfa in 15 minutes with a scythe.)
Too high  Too low  Just Right
SUGGESTED POTENTIAL LEAF CROPS

As of April 1993 I would recommend one of the following leaf crops to people who would like to begin working with leaf concentrate and who do not want to get involved with any crop testing:

- *Medicago sativa* (alfalfa or lucerne)
- *Vigna unguiculata* (cowpea)
- *Trifolium alexandrium* (berseem clover)
- *Dolichos lablab* (lablab or hyacinth bean)
- *Clitoria ternatea* (butterfly or Kordofan pea)
- *Brassica oleracea* (collards or kale)
- *Brassica juncea* (mustard)
- *Beta vulgaris var. cicla* (Swiss chard, acelgas)
- *Atriplex hortensis* (orach, mountain spinach)
- *Triticum x aestivum* (wheat, trigo)
- *Manihot esculenta* (cassava, manioc)
Below is a more extensive listing of plant species that have been recommended by various workers as sources of leaf concentrate. I’ve tried to give some of the pros and cons of each along with some other notes and sources of seed. Addresses of listed seed companies are at the end of this section. There is not a lot of information available on some of the crops, and some of these may prove to be unsuitable after further studies are done. We will try to keep this list updated to include information as it comes to us. Please send us any relevant information you might have gathered on any of these crops or on others that you feel should be included in this list. Thanks!

**LEGUMES (ANNUALS)**

**Canavalia ensiformis - Jack Bean**

*Tropical/Subtropical*

**Pros:**
- grew very well in trials at San Juan del Sur, Nicaragua
- both jackbean and swordbean (C. gladiata) leaves are eaten as potherbs in Asia
- easily established
- withstood long dry season well

**Cons:**
- possibility of toxicity; green beans are reportedly toxic
- no information on how well it coagulates or processes

**Notes:**
- closely related to C. gladiata (swordbean) another useful tropical legume used as a green manure but with strong possibility of toxicity problems

**Seeds:**
- ECHO
- Banana Tree
- J.L. Hudson Seedsman
- B &T Associates
- Kumar International
- Phoenix Seeds
- Inland and Foreign Trading Co., Ltd
- Setropa Seeds
Crotalaria juncea - (C. ochroleuca) Sunnhemp, Sun Hemp

**Pros:**
- top performer for weight and speed of growth in Muniguda trials in India
- processed easily
- yielded over 5% LC and tasted good
- very high dry matter yields reported (8-20 ton/ha)

**Cons:**
- somewhat poisonous to livestock, should not be fed at over 10% of fodder ration
- not well known as a food crop
- can't recommend until toxicity questions are resolved

**Notes:**
- most of the work on sunnhemp has been relative to its value as a bast fiber
- much used as a green manure, less as hay or fodder,
- seeded at 50-240 kg/ha; but heavy seed rate is to insure upright stems for long fibers and may be negative factor to leaf yield
- yields 25% lower without weeding
- 2 cuts can be taken if first is at height of 30-35 cm from ground

**Seeds:**
- ECHO;
- J.L. Hudson Seedsman;
- Hurov's Tropical Seeds;
- Peaceful Valley Farm Supply;
- Setropa Seeds;
- Inland and Foreign Trading Co., Ltd

Cyamopsis tetragonolobus - Guar, or Cluster bean

**_Tropical/Subtropical_**

**Pros:**
- did well in trials at Muniguda in India
- reported good yield when closely planted and good tasting curd
- leaves eaten in Africa, young pods, and immature as well as mature seeds also eaten
- seeds contain powerful thickening agent with commercial value
- 81% moisture in leaves
- extremely tolerant of salinity (second only to Atriplex)
- uses cowpea EL type inoculant
- N fixation similar to cowpeas

**Cons:**
- green crop yield considerably lower than cowpeas and other tropical legumes
- requires high levels of phosphate in soil (200-250 kg/ha) though his increases yield of following crops

**Notes:**
- bushy plant to 3 meters tall
- needs 400-500 mm annual rainfall, 900 mm optimum
- high rainfall and heat best for green crop, but lowers quality and yield of seed
- prefers pH 7.5-8.0
- seed planted 2.5-3 cm deep at 8-15 kg/ha
- didn't break down as quickly as Crotalaria juncea in green manure trial in India;
- may need at least two months before following crop is planted
best forage yields at 51 cm between rows

*Seeds:* - ECHO;  Banana Tree;  J.L. Hudson Seedsman;  Peaceful Valley Farm Supply;  B &T Associates;  Kumar Internationa;  Setropa Seeds

**Dolichos lablab** *(Lablab purpureus)*- Lablab Bean, Hyacinth, Bonavist, Jacinto, Gallinita, Poroto de Egipto, Frijol de Adorno, Tonga Bean.

*Tropical/Subtropical*

**Pros:** leaves eaten both fresh and dried
- one of top selections from Puerto Rico LC trials of tropical plants
- large seeds good for drilling
- retains foliage longer than cowpeas
- drought tolerant
- grew very well in trials in San Juan del Sur, Nicaragua
- good nitrogen fixation even without inoculant
- recommended by Ram Joshi in India and by Telek in Puerto Rico
- fodder yields of 5-10 ton/ha dry matter have been reported
- successfully intercropped with corn
- young pods and mature seeds have commercial value in many countries; used as vegetable, tofu, tempeh, sprouts. also has large starchy edible root.  good multi-purpose crop

**Cons:** slow early growth
- yielded poor curd and small quantity in Nicaraguan field test
- lablab forage has reportedly affected the flavor of milk from cows
- high percentage of vines and stems may make pre-chopping necessary
- reportedly very sensitive to flooding

**Notes:** very poor regrowth when cut below 25 cm
- benefits greatly from superphosphate application (250 kg/ha)
- Highworth and Rongai good forage varieties
- 89 % moisture in leaves ; 86 % in stems
- 400 mm minimum rainfall, 750 - 1000 mm is optimum, over 2500 mm unacceptable
- with dense growth lower leaves are shed.; they are lost for LC but make good mulch
- can cause bloat in cattle
- makes good silage with 2 parts sorghum; protein is 8.1% vs. 4.5 % for plain sorghum forage.
- often takes four days for cattle to accept lablab forage
- 75% germination of seeds
- some damage from leaf-eating insects and nematodes reported
- seeding rates reported at 20-70 kgs/ha seed for dense stand
- needs water for 10 weeks then very drought resistant
sometimes seeded between coffee trees, after 2 months further weeding is unnecessary

fresh seeds may contain dangerous levels of hydrocyanic acid, darker colored seeds contain more; need very thorough cooking and change of water

*Seeds:* ECHO; J.L. Hudson Seedsman; Hurov's Tropical Seeds; B &T Associates; Setropa Seeds; Queensland Agricultural Seeds Pty., Ltd; Primac Seeds; Phoenix Seeds

**Mucuna deerianga or Mucuna spp - Velvetbean, Terciopelo**

*Tropical/Subtropical*

**Pros:**
- grew very well in trials at San Juan del Sur, Nicaragua
- widely promoted throughout Central America by International Clearing House on Cover Crops
  - good nitrogen fixation (up to 200 kg/ha)
  - easily established
  - withstood long dry season well

**Cons:** likelihood of toxicity. Even the Clearing House cautions against using velvetbean in quantities equal to other pulses. Most of the participants in a velvetbean demonstration in Nicaragua experienced nausea and headache. Too little is known about the chemistry of the leaves and the variation in their composition from variety to variety and under different agricultural conditions. It also appears that sensitivity to toxins from velvetbeans varies greatly from person to person.
  - it can be extremely tangled and presumably difficult to harvest as a result

**Notes:**
- a commercial source of L-Dopa used in treatment of Parkinson's Disease
- sometimes called *M. pruriens*
- seeds usually sowed 15-90 cm apart in rows 90-180 cm apart; broadcast doesn't work well
  - c. 35-45 kg/ha; or 15 kg/ha when intercropped with corn
  - 2-3 cultivations usually necessary to control weeds until plants start vining
  - cowpea inoculant can be used
  - dense plantings don't produce good seed yields because of poor air circulation

*Seeds:* ECHO; J.L. Hudson Seedsman; Hurov's Tropical Seeds; B &T Associates; Setropa Peace Seeds; Glendale Enterprises, Inc.; Inland and Foreign Trading Co., Ltd

**Phaseolus lunatus L - Tropical Lima Bean, Madagascar Bean**

*Tropical*

**Pros:**
- well suited to leached low fertility soils common to humid tropics
- shows great promise in African rainforest, a difficult environment for pulses
- leaves eaten as a minor potherb when young and tender in parts of Latin America and Africa
green and dried beans have commercial food value
successful intercrop trials with corn in Columbia

**Cons:** most of the breeding has been for seed yield, bushy growth habit, and adaptability
to temperate zone; none of which serves our purpose
not well tested as LC source
seeds require longer cooking time than other pulses and may contain dangerous
amounts of HCN. White seeds usually safe; dark seeds need to be boiled very thoroughly
and have water thrown out

**Notes:** has perennial as well as annual forms
viny unselected varieties performed better than improved bush type in African trials
indigenous to South, and Central America and the Caribbean
seed harvest varies from 3-9 months with 5 months typical

**Seeds:**- ECHO; Eden Seeds

**Phaseolus vulgaris - Common Bean, Frijol.**

**Temperate/Sub- Tropical**

**Pros:** leaves eaten as a vegetable in much of Africa and Asia
very well known and accepted
seeds widely available
seeds and immature pods have strong commercial market

**Cons:** slower starting than cowpeas
seeds normally selected for seed yield at expense of foliage
usually do poorly in very wet tropics
most cultivars can't tolerate standing water even for a few hours

**Notes:** prefer cooler subtropics, 800-2000 meters, usually cowpeas will do better in
humid lowlands
cultivation must be shallow, especially in closely planted rows to avoid root
damage.
usually planted in rows 70 - 80 cm apart, 5-10 cm between seeds, and 5 - 8 cm
deep
in Nicaragua are normally planted in rows 80-90 apart. This is tied to the space
needed to cultivate with oxen. We are testing a system of planting beans in rows 16” apart
with the wheel seeder and cultivating them with the wheel hoe. When they get too
crowded we harvest every other row to make leaf concentrate. This system could
potentially produce far more nutrients per acre with less work. By having an extra row of
beans between the wide rows, weeding would be easier, the soil would be improved and
the land would yield leaf concentrate and fiber for animals as well as beans.
c. 87% moisture; 3.6% protein in fresh leaves
bean leaf yield usually improves markedly with added phosphorus in the soil
small seeded pole types should produce more foliage than bush types, half runners are intermediate
many varieties used for centuries as intercrop with corn; 70% of beans in Latin America are intercropped
over 14,000 cultivars worldwide with very large variety of characteristics
seeding rate of 100 kg/ha probably good for foliage; as low as 25 kg/ha for beans;
with lower seeding rates for pole types than bush types
bush beans are normally planted 5-8 cm deep; in rows 50 cm apart; with 5-10 cm between seeds
inoculation of seeds usually not necessary

umbledore - Moth Bean or Mat Bean
Tropical/Subtropical
Pros: relatively well known bean crop
forage 75% moisture;
7.5 - 10 tons/ha dry matter
excellent forage and green manure crop
very drought resistant
adapted to very hot climates

Cons: low creeping growth habit could make this crop difficult to harvest and to clean
not well tested as LC crops
not eaten as potherb

Notes: prefers dry sandy soils
prefers 500-7500 mm rainfall
sea level to 1300 meters
Seeds: - J.L. Hudson Seedsman; Hurov’s Tropical Seeds; Seeds of Change

Vigna unguiculata - (Vigna sinensis) Cowpeas, Frijol de Vaca
Pros: well known to be edible, leaves eaten as vegetable in many African and Asian countries.
seeds easily available commercially and very easy to propagate
germinates well
grows very quickly compared to many tropical legumes enabling it to get over weeds with one cultivation
good yield of mild flavored leaf curd

Cons: Somewhat prone to virus
Sensitive to frost and flooding
Annual that won’t take repeated cuttings, needs replanting at least every 12 weeks

Notes: moisture content 85-89%; protein much higher at 89% than 85%
huge number of cultivars are commercially available including California blackeye #5, Magnolia, Mississippi, and Vining Purple Hull that have been bred for resistance to fusarium, root knot nematodes, wilt and other viruses

most of the breeding for resistance has been done with bush type heavy seed yielding varieties, whereas the best foliage varieties like Iron and Clay, and Whippoorwill have not been bred much for resistance. Disease has not been a big problem in Nicaragua over 4 years.

March 1993 report from Nicaragua shows harvests of irrigated cowpea forage at about 550 grams per square meter. estimated 57 tons/ha green crop per year

Dry LC is about 2-2.25 % of fresh crop or c. 1.4 tons dry LC per ha per year or enough LC for about 930 children to receive a 6 gram portion M-F all year.

- research on cowpeas is being done at International Institute of Tropical Agriculture N.Q. Ng Head OYO Road PMB 5320 Ibadan, NIGERIA tel: 400300 400314 whose European contact is: IITA c/o Ms. Maureen Larkin, Carolyn House 26 Dingwall Rd. Croydon CR9 3EE UK fax 44 81 681 8583. They may be willing to provide test packets of cowpea varieties.

Seeds: widely available. Iron and Clay, and China Red are the most widely available forage types in the US. Inoculant from Peaceful Valley Farm Supply~~P.O. Box 2209~Grass Valley~CA 95945, USA tel:= 916 272 GROW FAX= 916 272 4794 or Liphatech 3101 W. Custer Ave. Milwaukee, WI 53209 USA tel: 414 462 7600 or from many larger seed dealers. Typical price $20 US for 50 lb (c.23 kg) sack.

**LEGUMES (PERENNIAL)**

*Calopogonium mucunoides* - Calopo

Tropical

**Pros:**
- Native to Nicaragua, well suited to humid tropics
- Tolerates acid lateritic soils
- Yielded c. 60 ton/ha green manure in 6 months
- Nearly 250 kg/ha N fixation
- A self-regenerating annual with good seed production
- Can also be propagated from stem cuttings

**Cons:**
- Not known as a human food
- Forage not palatable to cattle
- Shallow rooted so doesn't withstand long drought
- Needs at least 850 mm rainfall, prefers 1250 mm

**Notes:**
- Forms complete cover crop 60 cm thick in 5 months
- Often intercropped with citrus, rubber and coconuts
Centrosema decumbes, *C. pubescens* - Centro

*Centro, Tropical*

**Pros:** very leafy perennial legume
  - easy to establish on poor soil

**Cons:** not known as a human food
  - not very palatable to cattle

**Notes:** 5-7 tons/ha dry matter reported
  - 4-8 months to form dense cover 40-50 cm high
  - for forage sow 8 kgs/ha in rows 90 cm apart; more if broadcast at onset of rainy season
  - stems are not woody for the first 18 months
  - Sometimes planted with *Calopogonium mucunoides* or *Pueraria phaseoloides* for quicker cover

*Seeds:* J.L. Hudson Seedsman; Setropa Seeds; Queensland Agricultural Seeds Pty., Ltd; Kenya Seed Co; Inland and Foreign Trading Co., Ltd; Dumon Agro NV

**Clitoria ternatea** - Butterfly or Kordofan Pea., Campanilla, Zapatilla de la Reina.

*Tropical*

**Pros:**
  - given top rating by Telek in terms of % protein in dry LC (59.3%) and PER or Protein Efficiency Ratio (2.4) in Puerto Rico trials
  - moisture content of green crop 79%
  - perennial legume
  - green matter yields of 80 - 100 kg/ha + recorded in Campeche, Mexico and in Cuba
  - dry matter yields of 13 tons/ha have been recorded in Australia
  - tolerant to drought, alkalinity, slope, virus, and weeds
  - can use cowpea EL type inoculant
  - very palatable to cattle

**Cons:**
  - no experience with making or using Clitoria LC on other than lab scale
  - much lower yield without inoculant and lower protein content
  - won't tolerate waterlogging
  - slow germination 7-15 days. We've had poor germination twice in Nicaragua

**Notes:**
  - prefers full sun
  - twiner; stem grows to 5 meters
grows from sea level to 1800 meters
rainfall minimum of 400 mm, optimum 1500 mm; does well with irrigation
flowers cerulean blue, used to tint boiled rice, as litmus substitute, as ornamental
covers the ground in 4-6 weeks when sown 25 cm apart in rows 1 meter apart,
dense enough to smother weeds in 4-6 months
dry matter yields vary greatly from 1 ton/ha in rainfed sandy soil to 13.5 tons/ha in
irrigated clay.
grown with Sudan, elephant grass, sorghum and sunnhemp
sown 1-3 kg/ha on well prepared seedbed
nitrogen application depresses growth
virus problems under wet conditions at Turrialba, Costa Rica
some grasshopper and nematode problems in Africa
young pods eaten as green beans

**Seeds:** - ECHO; Banana Tree; J.L. Hudson Seedsman; Chitern Seeds; Inland and Foreign Trading Co., Ltd

**Desmodium intortum; D. discolor ; D. nicaraguaense - Greenleaf**

**Pros:** perennial legumes can go 6 years if phosphorus supplied, often 3 without
can utilize cowpea inoculant
D. nicaraguaense used as forage in Central America, called horse-fattener because
of palatability and feed value
up to 7 cutting per year in Costa Rica.
grows up to 6 meters but usually cropped back by livestock
can withstand heavy competition from grasses

**Cons:** not known as human food
genus contains several obscure toxins
forage reportedly high in tannins, though lower tannin Australian cultivar
"Greenleaf" is available
leaves of D. intortum stick to clot h making harvest difficult

**Notes:** native to South America usually above 500 meters
several closely related and frequently confused species
propagated by seed (c. 6 kg/ha) or cuttings 15-30 cm long
usually grown with a grass
frequent weed in coffee plantations
cuttings below 8 cm can destroy plants
annual dry matter yield (c. 8 tons/ha) best with 12 week harvest intervals

**Seeds:** - Setropa Seeds; Queensland Agricultural Seeds Pty.,Ltd; Kenya Seed Co.

**Glycine wightii** (Glycine javanica) - Perennial soybean

**Tropical**

**Pros:** perennial legume
Macroptilium atropurpureum (Phaseolus atropurpureus) - Siratro

**Pros:** native to Mexico and Central America
- long-lived perennial
- deep taproots provide drought resistance
- tolerates alkaline soil and high aluminum levels
- can use cowpea inoculant

**Cons:** disease prone in very humid regions

**Notes:** prefers subtropical conditions to 2000 m or drier tropics (700 cm per year)
- prefers deep sandy soil
- can't tolerate waterlogging
- more tolerant of low fertility than Desmodium intortum or Glycine wightii, less than Stylosanthes humilis
- won't tolerate high manganese in soil as well as other legumes
- plant at beginning of rainy season
- typical seeding rate c. 3-5 kgs/ha
- benefits greatly from phosphate fertilizer as a rule
- yield increases as cutting interval is extended from 4 to 16 weeks
- up to 11 tons/ha dry matter with 4 cuts; average 5-7 tons dry matter with 2 cuts per season
- 70-75% moisture

**Seeds:** Setropa Seeds; Queensland Agricultural Seeds Pty., Ltd; Kenya Seed Co; T.S.L. Ltd

Macroptilium lathyroides - Phasey bean, Wild pea bean

*Tropical/Subtropical*
**Pros:** selected by Telek as one of most promising tropical LC plants in Puero Rico
  high protein
  good extraction
  very palatable to cattle
  rapid regrowth forms dense stand
  could be machine harvested
  good nodulation
  tolerant of waterlogging
  5-12 tons/ha dry matter reported; claim made of 60 tons/ha dry matter potential with irrigation

**Cons:** not known as a human food
  seeds difficult to gather due to shattering
  sensitive to viruses
  sensitive to frost
  seed not readily available commercially

**Notes:** annual or short lived perennial
  typical seeding rate 1-3 kg/ ha
  protein highest at 79% moisture at 4 months; at 6 months 70% moisture and only 2/3 the protein per kg dry matter

**Seeds:** Zentralinstitut fur Genetik und Kulturpflanzen-forshung~Correnstrasse 3~4325 Gatersleben~GERMANY (non-commercial source; small samples to institutions)

**Medicago sativa - Alfalfa (including tropical varieties)**

*Temperate/Subtropical*

**Pros:** best tested of all LC plants
  only plant used to make LC commercially
  deep rooted perennial legume
  yields up to 100 tons green crop/ha with irrigation
  withstands repeated cutting (8 to 15 cuts per year in Mexico)
  dense and erect growth ideal for harvest with scythe or sicklebar cutter
  80 - 83 % moisture, 5 - 6 % protein

**Cons:** strong flavored curd due to saponins; stronger if not well pressed
  attacked by virus and other diseases in hot humid climates

**Notes:** tropical varieties have been developed at the University of Florida and in Brazil. these do better in heat but still have problems compared to tropical natives
  In Aurangabad, India alfalfa yielded 150 t/ha fresh crop; 25 t/ha DM; (16.7%) 6t/ha CP; 3.2 (2.13% of green matter ; 12.8% of DM) t/ha extracted protein, with 14-16 harvests per year. Yields were increased by frequent irrigation, NPK, manure and micronutrients, simazine, and closer rows (30 cm rather than 46 cm) and frequent harvest; 8 rather than 5 in 180 days
alfalfa is a potential source of a variety of medicinal and industrial compounds. Research has begun at the University of Wisconsin to commercially extract compounds from genetically altered alfalfa. This could potentially be integrated into an LC production scheme.

seeds are very hard and should be scarified or soaked in water before planting. Fresh seed does not germinate as well as seed that is 2-3 years old.

when broadcast seed rate suggested as 12-20 kg/ha; in rows or ridges 55-72 cm apart 10-12 kg/ha seed used. Ridges or rows facilitates weeding usually responds to 250 kg/ha superphosphate per year or 500 kg/ha every other year; also often responds to potassium and sometime s boron

best harvested at beginning of flowering

optimum rainfall usually 500-600 mm, where there is over 1000 mm it sometimes grows only as an annual

in Michoacan, Mexico (c.2000 meters) yields c. 80 tons/ha green matter per year with irrigation; which should yield 1.6 tons dry LC ; enough for 1060 children at 6 grams daily

good alfalfa sells for $40-70 US per ton in the field in Michoacan, Mexico

low saponin varieties should be used for LC production

Seeds: normally available commercially in alfalfa growing regions. Small packets of tropical varieties from - ECHO; non-hardy, heat resistant variety CUF 101 (grown in California's Central Valley) is available from - Cal/West Seeds; also Ramsey Seed Co; Gunson Seed

Psophocarpus tetragolonoobus - Winged bean, Goa bean

Tropical

Pros: leaves eaten as vegetables

85% moisture, 5% protein

one of top performers in Puerto Rico LC trials; PER of 2.2; behind only Clitoria ternatea

used as green manure, forage, cover crop, fresh and dried beans, and edible tubers;
the ultimate multi-purpose crop

tolerates heat and low pH

apparently can utilize cowpea inoculant

Cons: needs good drainage

uses lots of water 1500 mm for good growth; 2500 mm or more for top production

little information on leaf yields as it is grown mainly for beans or tubers
difficulties in germination in Nicaraguan trials

slow starter, needs weeding until established

forms tangled mess of vines that could be difficult to harvest and pulp

Notes: perennial vine, but often grown as an annual

sea level to 2000 meters
typically planted 2.5 - 7.5 cm deep c. 10 cm apart for foliage, at beginning of rainy season
trellised plants produce twice the seed of unstaked plants
picking flowers increases tuber yield

*Seeds*: - ECHO; Banana Tree; KEO Entities; B & T Associates; Sutton and Sons,(INDIA); Phoenix Seeds; Inland and Foreign Trading Co., Ltd; Tokita Seed Co., Ltd; Setropa Seeds

**Pueraria phaseoloides (P. javanica) - Puero or Tropical Kudzu**

*Pros*: perennial tropical legume
considered very palatable to livestock
does well in high rainfall areas (over 1000 mm per year) if dry periods is not too long
good at smothering weeds once established
recommended from Venezuelan trials

*Cons*: not used as a green for humans, little information available on its use for humans
heavy twining habit with extremely tough fibrous stems (used in ropemaking in some places) could make it hard to harvest and to pulp
slow to establish cover

*Notes*: 30 - 50 tons green crop/ha possible

*Seeds*: - Banana Tree; Hurov's Tropical Seeds; Primac Seeds; Setropa Seeds; Dumon Agro NV~715

**Stylosanthes gracilis (guianensis) - Brazilian lucerne, Stylo, Tropical alfalfa**

*Pros*: one of highest yielding legumes 15 tons/ha dry matter reported with irrigation and fertilizer; 17 - 21 tons/ha dry matter per year considered possible
can utilize cowpea inoculant
can accumulate calcium and phosphorus even when levels of these nutrients are low in the soil
tolerates high aluminum in soil

*Cons*: not known as a human food
can't tolerate shade
susceptible to leaf spot infection

*Notes*: typical seeding rate 3 kg/ha broadcast or in rows 45 - 60 cm apart
benefits from 1 or 2 weedings until established (usually 3-5 months)

*Seeds:* - Setropa Seeds

**Trifolium alexandrium** - Berseem or Egyptian Clover

---**Subtropical**

**Pros:** has been successfully used as LC source in Pakistan, India, and Egypt

- excellent productivity (8-10 tons/ha dry matter with 3 cuts and no irrigation; and 12-18 tons/ha dry matter with 6-8 cuts and irrigation). Generally 2 tons/ha dry matter per cut, yields up to 170 tons green fodder/ha are possible
- more succulent stems than alfalfa, up to 90% moisture; therefore less energy required for grinding

**Cons:** prefers warm temperate climate (12-25 °C), cooler than most of the humid tropic locations.

**Notes:** seed rate 22/50 kgs/ha planted early in wet season

- 1.3-2.5 cm deep
- needs minimum of 250 mm annual rainfall
- won't tolerate frost
- tolerates high pH and virus
- can use commercial white clover inoculant, molasses or other sticking agent helps inoculation
- phosphorus, zinc, copper and boron can become limiting factors
  - Feb 93 report from India shows Berseem with 87-91% moisture and yielding 32 grams of fresh leaf curd per kg fresh berseem

*Seeds:* - ECHO; Peaceful Valley Farm Supply; Kaufman Seed, Inc.; Harmony Farm Supply; Empresa de Semillas Forrajeres

**LEGUMES (PERENNIAL TREES AND SHRUBS)**

**Erythrina variegata** - Tiger's Claw, Indian Coral Tree

**Erythrina poeppigiana** - Poro

---**Tropical/Subtropical**

**Pros:** used in living fencepost schemes and intercropped with coffee in Costa Rica

- produced more foliage than Gliricidium sepium, though less than Leucaena in Indian trials
- lower polyphenol concentration in leaves than Cajanus cajan
- goat milk production increased with E. poeppigiana leaves added to banana and king grass rations
- E. poeppigiana leaves and sugar cane juice successful feed for rabbits and guinea pigs
Cons: foliage not known as human food  
great genetic variation in quantities of alkaloids present in leaves  
very little known about LC production from these plants

Notes: Tested extensively at CATIE in Costa Rica  
E. indica leaves in water (5 grams to 15 ml) said to kill nematodes

Seeds:- Hurov's Tropical Seeds; Peace Seeds; J.L. Hudson Seedsman

Gliricidium sepium - Mother of Cacao
______________
__Tropical/Subtropical

Pros: commonly used in agro-forestry schemes  
living fence  
flowers eaten as potherb or fried

Cons: leaves not known as a human food  
yielded much less foliage than Erythrina in Indian trials

Notes: established more quickly than Erythrina in Nicaraguan trials, though Erythrina caught up  
within 1 year

Seeds:- Banana Tree; J.L. Hudson Seedsman; B &T Associates; Kumar International; Inland and Foreign Trading Co., Ltd

Sesbania grandiflora & S. sesban - (Gallito, Sesban)
__Tropical/Subtropical

Pros: extremely fast growing small tree; especially first 3-4 years; often 4 meters 1st year; 8 meters by 3rd  
one of best nitrogen fixers  
widely used as green manure  
seed and inoculant readily available  
nodulation excellent often even without commercial inoculant  
76 % moisture and 8.7 % protein  
great potential in reforestation and land reclamation schemes  
excellent potential for firewood in 5 year cycle  
can be planted very densely (c. 3000 stems per ha)  
resprouts vigorously after cutting to stay within height cattle can reach (or people)  
leaves palatable to cattle

Cons: difficulties with germination  
foliage quickly stripped by insects in Nicaragua trial  
photoperiod sensitivity in some varieties
Notes: In Java yields of 55 ton/ha green matter in 6-7 months, far better than Crotalaria in same experiment
  S. rostrata in Senegal showed potential N fixation of 270 kg/ha in 45 days
  biomass and N fixation faster with stem cuttings than seeds
  Ratooning (cutting at or near base and allowing regrowth) gave top yields

Seeds: Peaceful Valley Farm Supply; ECHO; Banana Tree; J.L. Hudson Seedsman; B &T Associates; Kumar International

AMARANTHS AND RELATIVES
Celosia argentea - Quailgrass, Soko
  Tropical/Subtropical
Pros: has been used in Africa as a green pot herb
  used to make leaf concentrate, called Sokotein
  did well in trials in Tennessee

Cons: curd was unappealing near black color
  requires high levels of nitrogen in soil for top yield

Notes: an amaranth with many attributes similar to A. tricolor
  beautiful purple flowers
  edible oil sometimes extracted from seeds on small scale in Africa

Seeds: ECHO; Hurov's Tropical Seeds; B &T Associates

Alternanthera sissoo (A. sessilis, A. ficoidea?) - Brazilian spinach
Pros: one of top three candidates in TRIADES LC trials in Hawaii
  used as cooked vegetable
  spreads to smother weeds
  non-twinning

Cons: propagated from cuttings
  low growing, creeping plant may be difficult to harvest in economically viable quantities (200 - 500 kgs per day) rapidly and without a lot of soil getting into the leaf grinder

Notes: flowers sometimes eaten
  member of amaranth family
  not well known

Seeds: Hurov's Tropical Seeds; Gleckler's Seedsmen; B &T Associates
Amaranthus tricolor - Bledo forajero

*Tropical/Subtropical*

**Pros:**
- comes up quickly, can often be harvested in 3-4 weeks
- large yields possible under intensive cultivation
- c.85% moisture in green crop
- pan-tropic
- seed readily available
- regrowth up to 4 harvests
- protein quality excellent for leaf crop
- tolerates high aluminum content in soil

**Cons:**
- often worked with in LC projects but usually yields poorly
- some tests have given very fine curd that is difficult to separate
- badly attacked by damping off in Rivas, Nicaragua
- very dependent on nitrogen fertilizer for good yields
- doesn't grow well during long periods of cloudy or rainy weather or in partial shade
- prone to bolting (premature setting of seed)

**Notes:**
- numerous amaranth species, including A. cruentus, A. hypochondriacus, A. caudatus are grown for grain-like seeds. Often green shoots and thinnings from these crops are eaten casually as greens.
- some wild amaranths, notably A. retroflexus, A. spinosis, and A. hybridus are often serious weeds. They are eaten as greens sometimes as well., but are not useful sources of leaf concentrate.
- leaves are high in oxalic acid, but most of the free oxalic acid will wash out with "whey" and the crystalline oxalic acid normally passes through the body without bonding with calcium. Free oxalic acid can bond with calcium, which makes the calcium less available to the human body and can lead to calcium oxalate kidney stones in some people.
- leaves high in nitrates, especially in dry weather or when grown with high levels of nitrogen fertilizer. Almost all of the nitrates will also wash out with the "whey"
- sometimes transplanted at 2-3 weeks when 2-4 leaves are on plant
- slugs and snails often damage young plants
- vegetable amaranths have more trouble with insects as a rule than grain amaranths
- c. 87 % moisture; 3.5 % protein

**Seeds:**
- J.L. Hudson Seedsman; Hurov's Tropical Seeds; Peace Seeds; Redwood City Seed Co; Burpee & Co; B &T Associates

**BRASSICAS**

*Brassica carinata* - Ethiopian collards, Texsel greens

*Temperate/Subtropical*

**Pros:**
- Excellent flavored greens and curd
very fast growing
one of the most heat tolerant brassicas
most salt tolerant brassica
most waterlogging tolerant brassica

Cons: somewhat prone to bolting
heavy nitrogen user
least drought resistant of leafy brassicas in Indian trials

Notes: breeding program at Texas A & M was promoting this crop as Tamu TexSel

Seeds:- Texas Foundation Seed Service;  ECHO;  J.L. Hudson Seedsman;  B &T Associates

Brassica juncea (B. alba, B. nigra) - Mustard, Mostaza.

Temperate

Pros: erect fast growing plants
did well with wheat in early Rothamstead trials
grew very well in San Ignacio, Nicaragua despite hot humid climate

Cons: When large amounts were ground quickly in Nicaragua, workers experienced burning sensation on eyes and skin
90-92 % moisture and 2.4-3 % protein is marginal in terms of dry matter for economic production

Notes: Grown in India for LC with seeding rate of 30 kg/ha

Seeds:- Banana Tree;  J.L. Hudson Seedsman;  Burpee & Co;  B &T Associates
-hundreds of varieties; seed widely available

Brassica oleracea var. acephala - Collards, Kale, Col Foragera

Temperate

Pros: 83 % moisture, 4 -6 % protein
grow quickly
well recognized as edible leaf crop
tree, thousand headed, and walking stick kale varieties produce huge leaves on tall strong plants

Cons: very slow regrowth
sometimes a strong cooked cabbage smell to curd
need cool nights

Notes: goitregens that limit usefulness of brassicas as forage crops are destroyed by heat in LC process; however, they may remain in the fiber in significant quantity to affect milk.
They are passed from forage to milk and can cause iodine deficiency in children who drink this milk.

Seeds: -Burpee & Co.; Redwood City Seed Co; Chitem Seeds; B &T Associates; Eden Seeds --numerous varieties; seed widely available

**CHENOPODS**

**Atriplex hortensis** - Orach, Mountain Spinach

*Temperate*

**Pros:**
- did very well in Rolf Carlsson's trials in Sweden
- salt tolerant
- eaten as green

**Cons:**
- heavy nitrogen feeder
- prefers cooler climate

**Notes:**
in chenopodium family; some members of genus, especially *A. nummalaria*, are among most salt tolerant plants known. It exudes salt onto leaf surface. Palatable and high in protein but salt content makes livestock thirsty in low water areas. It is possible that LC process would offer a reasonable way to wash out salt in whey and greatly improve value of this crop in saline areas. *A. HALIMUS* will produce palatable forage when irrigated with saline solution of 30 g/liter of sodium chloride.

Seeds:- J.L. Hudson Seedsman; Abundant Life Seed Foundation; Peace Seeds; B &T Associates

**Beta vulgaris** - Common beetroot, Remolacha

*Temperate*

**Pros:**
- by-product leaves of popular root vegetable
- beet greens are eaten as a vegetable in many places

**Cons:**
- very fine curd is somewhat difficult to separate
- leaves may be past peak when root reach maximum weight

**Notes:**--numerous varieties; seed widely available

**Beta vulgaris var. cicla** - Swiss Chard, Acelgas

*Temperate*

**Pros:**
- popular leaf vegetable in Mexico and India
- some varieties well suited to repeated harvest including Erbette, Perpetual, and Markin Giant

**Cons:**
- very fine curd is somewhat difficult to separate
Notes: includes leaf beets, which are beets grown for leaves as well as some Japanese cultivars that are midway between chards and leaf beets.
- numerous varieties; seed widely available in areas where crop is grown

Chenopodium album - Lambsquarters, Fat Hen

Temperate

Pros: did very well in Rolf Carlsson's trials in Sweden
- a common weed in disturbed soil
- eaten in northern Mexico as Quelite, a spinach substitute
- 82% moisture

Cons: prefers very rich land

Notes: related plants including C. bonus henricus (good King Henry) and C. quinoa also can be used to make leaf concentrate.
- Luis Fuentes in Bolivia reported that quinoa leaves were too dry to extract well, but they may have a higher moisture content grown in a wetter area than the Bolivian Altiplano

Seeds: J.L. Hudson Seedsman; Abundant Life Seed Foundation; Bountiful Gardens; B &T Associates

GRAINS

Avena sativa - Oats, Avena

Temperate

Pros: used in Bareilly project in India

Cons:

Notes: similar to wheat
- numerous varieties; seed widely available in areas where crop is grown

Pennisetum glaucum (P. typhoides, P. americanum) - Pearl millet

Tropical/Subtropical

Pros: very fast growing c-4 crop
- good flavor to LC reported in India
- adapted to sandy soils with under 300 mm rainfall
- erect growth habit for easy harvest

Cons: tough and fibrous
- lower yield of LC than legumes
no N fixation, needs heavy N fertilizer for good crop
foliage not known as a food

Notes: macerator appears to be well suited to tough fibrous crops, especially non-viny ones
  slender leafy Egyptian varieties better than grain type
  81-86% moisture
  seeding rate c.5 kgs/ha

Seeds:- ECHO; Seeds of Change
  -numerous varieties; seed widely available in areas where crop is grown

Secale cereale - Rye
______________________________
  _______ Temperate

  Notes: similar to wheat
  used as a green manure sometimes because its vigorous branching roots open up soil and add organic matter along with the green tops
  perennial ryegrass (Lolium multiflorum) gave good LC yield in New Zealand trials
  -numerous varieties; seed widely available in areas where crop is grown

Triticosecale sp. - Triticale
______________________________
  _______ Temperate

  Pros: hardy to cold, reportedly grows well in Bolivian altiplano
  erect plant 120 -200 cm tall should be easily harvested with scythe
  seeds valuable grain crop

  Cons: needs nitrogen fertilizer for good yield
  doesn't thrive in humid tropics

Notes: a cross between wheat and rye

Seeds:- Good Seed Co.; Sharp Bros. Seed Co; Chambers Seeds

Triticum x aestivum - Wheat, Trigo
______________________________
  _______ Temperate

  Pros: used successfully in early trials at Rothamsted
  young wheatgrass extracts easily
  erect growth should be easily harvested with scythe or sickle bar cutter
  fall planted wheat could give very early forage harvest in spring in temperate zones

  Cons: needs nitrogen fertilizer for good yield
  doesn't thrive in humid tropics
Notes: Thinopyron intermedium (Intermediate wheatgrass) is a related species that may have more potential as LC source. It is being tested at Rodale Research Center as a perennial grain
- numerous varieties; seed widely available in areas where crop is grown

OTHERS (PERENNIAL TREES & SHRUBS)
Moringa olifera - Horseradish, Marango or Drumstick Tree, Benzolive, Malungay

Tropical/Subtropical

Pros: Indigenous tree in much of Central America
leaves eaten cooked
ECHO reported success making LC from moringa
good fencepost crop
a tree crop whose roots can get water and keep foliage green when field crops are brown
roots used as horeradish substitute
seeds reportedly yield good cooking oil (though we didn't have much success separating it in Nicaragua)
seeds reportedly useful for purifying drinking water
does well with low rainfall

Cons: we had trouble separating mucilaginous juice in Nicaragua, though ECHO reported good results
trees would be difficult to harvest 200 kg of leaves from compared to field crops

Notes: TRIADES reports African moringa (Moringa stenopetala) has larger and more palatable leaves and is generally more desirable

Seeds: - ECHO; Banana Tree; J.L. Hudson Seedsman; Kumar International; Pocha Seeds Pvt. Ltd. Inland and Foreign Trading Co., Ltd

Sauropus androgynus - Asparagus bush, Katuk, Sweet leaf bush

Pros: one of top three candidates in TRIADES LC trials in Hawaii
leaves can be eaten raw
growing tip is asparagus-like delicacy (it needs shade to be use as asparagus)
easily propagated from seeds or cuttings
adapted to wet tropics
YIELDS UP to 80 TONS GREEN LEAVES /HA reported
recommended as vegetable crop by Franklin Martin in Puerto Rico and by ECHO
leaves available year round
Cons: frequent usage reported to cause bodily pains
  speed of leaf harvest on small shrubby tree?
  Martin Price of ECHO reported a failure of Indonesian large plantation for shoots
  because of high labor requirements
    heavy N feeder

Notes: 81% moisture
  8-10 weeks to first harvest
  likes about 70% of full sunlight
  leaves used to color pastry, make fermented rice, and alcoholic drink
  fruits used to makes sweets in Southeast Asia
  needs high soil moisture for good shoot production, though shrub will survive
  much lower moisture

Seeds: - Hurov's Tropical Seeds; The Borneo Collection

Spondias purpurea - Jocote
  Tropical/Subtropical
Pros: indigenous scrubby tree crop in Nicaragua
  young leaves eaten occasionally raw or cooked, used as tea for colds
  possibilities as living fence
  make good yield of LC with pleasantly tangy flavor
  leaves 5.5% protein; low moisture

Cons: difficult to harvest economical quantities quickly
  little known about chemistry of leaves

Notes: S. mombin, S. lutin, S. mangifera, and S. dulcis all related plants whose somewhat
tart leaves are eaten either raw or cooked

Seeds: - Hurov's Tropical Seeds; B &T Associates; Kumar International

OTHERS (NON-WOODY)
Azolla pinnata
  Tropical
Pros: 2nd highest in dry matter (7.8%) of 16 water plants in Calcutta trials
  good quality LC
  aquatic fern that grows in association with nitrogen fixing blue-green algae
  may have potential as LC crop in places to wet for conventional field crops
  may have potential for use in rice paddy intercrop

Cons: higher moisture content 92% and lower extractability than legumes
Notes: suggested by TRIADES

Coccinia grandis  - Perennial cucumber, Ivy gourd, Scarlet gourd
Pros: one of top three candidates in TRIADES LC trials in Hawaii
  vigorous perennial
  leaves can be eaten raw or cooked
  cucumber like fruits eaten young or pickled
  reportedly used as living fence

Cons: wild relatives can become weed pest spread by birds, (to prevent this a sterile
cultivar is used which can only be propagated by cuttings)

Notes: Little information available on this crop as grown for leaves rather than fruit

Seeds: - Hurov's Tropical Seeds; B &T Associates

Crassocephalum biafrae - Sierra Leone Bologi
Crassocephalum crepidioides -Ebolo

Pros: well adapted to growing in light shade. Direct sunlight reported to reduce rate of
growth. This could be a valuable attribute for growing in agro-forestry or multi-storied
schemes or intercropped with coffee, banana or other large perennials.

Cons: little known about this crop as a source of LC
  succulent leaves could be mucilaginous
  propagated by cuttings, rarely by seeds. This makes importation of crop into areas
  where it doesn't already exist difficult.
  plants very sensitive to dry soil

Notes: young leaves and shoots eaten in tropical Africa
  more investigation needed before it can be seriously considered
  prefers soil with organic content
  plants normally established 60-75 cm apart with supports up to 1.5 meters
  flowering shoots removed to encourage leaf production
  leaf harvest begins in 60-70 days, continues for over one year depending on plant
  vigor
  yields c. 15 kg fresh leaf per plant per year

Seeds: - Hurov's Tropical Seeds

Manihot esculenta - Cassava or Yuca

Pros: leaves high in protein
good yield of LC
pan-tropic
could be one of the biggest protein producers in the tropics
cassava LC could be mixed with starchy cassava tubers to make nutritious food
Zaire study shows that some defoliation can increase tuber yield
in Nicaragua leaves continue to be green well into dry season
Columbian study indicates acceptable digestibility of cassava LC

Cons: may not be easy to harvest in large quantities
serious questions about digestibility of protein due to binding with phenolics
not recommended by Telek in Puerto Rico

Notes: chick studies need to be done
heating juice to boiling and pressing curd very well should remove c. 95% of hydrocyanic acid
Hydrocyanic acid content of tubers varies from c 14 mg/kg (sweet cassava) to 400 mg/kg (bitter cassava). Leaves from plants with bitter tubers have much higher HCN than leaves from plants with sweet tubers. Taste is not a reliable indicator of HCN activity.
added nitrogen tends to stimulate leaf production and depress tuber yield
c. 80 % moisture; 6% protein in fresh leaves (moisture content lower in older leaves)

Seeds: - Hurov's Tropical Seeds; B &T Associates
-numerous varieties; seed and cuttings widely available in areas where crop is grown

**Sesimum indicum** - Sesame, Ajonjoli. Tropical/Subtropical

**Pros:** produced good yield of mild flavored curd in Nicaraguan trials Cassava Leaf
leaves eaten raw in salads or as a potherb

Cons: Walt Bray reported trouble with mucilaginous juice in several trials in India and the US.

Notes: much grown for seed; little known about production of leaves

Seeds:- Kusa Reasearch Foundation; Chitern Seeds

**Silphium perfoliatum L.** - Temperate

**Pros:** produced very heavy yield in Italian trials
harvested twice (first week of June and mid August yielded up to 200 tons/ha green crop
a weed, should have potentia for breeding
**Cons:** not well known as a human food source
doesn't have easily available commercial seed

**Notes:** studied in several European countries

**Urtica dioica - Stinging nettle**

*Temperate*

**Pros:** young leaves are palatable potherb
very high in protein
used by Michael Cole in England

**Cons:** hairs on leaves irritate skin

**Notes:** leaf juice has been used as a rennet in preparing cheese
prefers rich moist soil of riverbanks
used to make herbal tea
reportedly has anti-fungal effect on plants

**Seeds:** - Abundant Life Seed Foundation; J.L. Hudson Seedsman

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**SOURCES OF SEEDS**

Many of the seed sources listed here deal mainly with very small packets of seeds, sometimes containing a dozen or fewer seeds. This may be enough to see if a plant will grow well in your area or to make a small sample of leaf concentrate. For economic production of LC you will need to develop much cheaper sources of bulk seed. Sometimes these are available locally through seed companies not listed here. You may be able to propagate your own seed from a small packet or two if the growing conditions for that plant are excellent. There are lots of rules restricting the movement of seeds between countries. You may need to get a phytosanitary document, declaring the seed to be free of pathogens like viruses from the seed source. Find out about this before ordering seeds, or they may be confiscated. Sources in bold type handle seed for several crops listed.

Abundant Life Seed Foundation ~ PO Box 772 ~ Port Townsend, WA 98368 ~USA
tel: 206 385 7192

**B &T Associates** ~ Whitnell House ~ Fiddington ~ Bridgewater ~ Somerset TA5 1JE ~ UNITED KINGDOM  tel: 278 733 209

**Banana Tree** ~ 715 Northampton St. ~ Easton ~ PA 18042 ~ USA ~ tel: 215 253-9589
The Borneo Collection~PO El Arish~QLD 4855~AUSTRALIA~tel: 70 685 263 (will ship plants to tropical countries, not US mainland)

Bountiful Gardens~5798 Ridgewood Rd~Willits~CA 95490~USA

Burpee & Co.~300 Park Ave.~Warminster~PA 18974~USA~tel: 1 800 888 1447

Cal/West Seeds~Po Box 1428~Woodland~CA 95695~USA

Chambers Seeds~15 Westleigh Rd.~Barton Seagraves~Kettering~Northants NN15 5AJ~UNITED KINGDOM~tel: 0933 681 632

**Chitern Seeds**~Bortree Stile~Ulverston~Cumbria~England LA12 7PB~UNITED KINGDOM~tel: 0229 581 137

Dumon Agro NV~Pathoekeweg 40~8000 Brugge~BELGIUM~tel: 32 050 315161; fax 050 315171 (large quantities only)

**ECHO** ~ 17430 Durrance Road ~ N. Fort Myers, FL 33917 USA tel: 813 543 3246

Eden Seeds~MS 316~Gympie 4570~AUSTRALIA~tel: 071 86 5230

Empresa de Semillas Forrajeres~Casilla 593~Tiquipaya~Cochabamba~BOLIVIA~tel: 41975

The Environmental Collaboration~ PO Box 539~Osseo~MN 55369~USA (5 tree minimum for each species) [seedlings]

Gleckler's Seedsmen~Metamora~OH 43540~USA

Glendale Enterprises,Inc.~Rt 3 Box 77 P~Defuniak Springs~FL 32433~USA~tel: 904 859 2141

Good Seed Co.~Star Rt. Box 73A~Oroville~WA 98844~USA~tel: 509 485 3605

Gunson Seed~Nature Rd~Zesfontein~7409~Petit 1512~REPUBLIC OF SOUTH AFRICA

Harmony Farm Supply~PO Box 451~Graton~CA 95444~USA~tel: 707 823 9125

**J.L. Hudson Seedsmen**~PO Box 1058~Redwood City~CA 94064~USA
Hurov's Tropical Seeds~PO Box 1596~Chula Vista~CA 92012~USA ~tel: 619 464 1017;619 426 0091

Inland and Foreign Trading Co., Ltd.~Block 79A~Indus Rd. # 04-418/420~SINGAPORE 0316~tel: 272 2711 or 278 2193

KEO Entities~ 348 Chelsea Circle~ Land O'Lakes~ FL 34639~ USA tel: 813 996 4644

Kaufman Seed, Inc. ~Box 398~ Ashdown, AR 71822 USA tel: 501 898 3328

Kenya Seed Co.~Elgon Downs Farm Research Centre~PO Box 13~Endebess~KENYA~tel: 0325 20941 (42 & 43)

Kumar International~Ajitmal 206121~ Etawah~Uttar Pradesh, INDIA

Kusa Reasearch Foundation~PO Box 761~Ojai~CA 93023~USA

Peace Seeds~2385 SE Thompson St.~Corvallis~OR 97333~USA~tel: 503 752 0421

Peaceful Valley Farm Supply~~P.O. Box 2209~Grass Valley~CA 95945, USA tel:= 916 272 GROW FAX= 916 272 4794

Phoenix Seeds~PO Box 9~Stanley~Tasmania 7331~AUSTRALIA ~ tel: 00458 1105

Plants of the Southwest~930 Baca St.~Santa Fe~NM 87501~USA~ tel: 505 983 1548

Pocha Seeds Pvt. Ltd.~PO Box 55~Near Sholopur Bazaar~Poona 411 040~INDIA~ tel: 671978

Primac Seeds~PO Box 943~Murwillumbah~NSW 2484~AUSTRALIA~tel: 6166 72 1866

Queensland Agricultural Seeds Pty.,Ltd.~PO Box 1052~Toowoomba, QLD 4350~ AUSTRALIA ~tel: 61 76 30 1000

Redwood City Seed Co.~PO Box 361~Redwood City~CA 94064~USA~ tel: 415 325 7333

Seeds of Change~621 Old Sante Fe Trail #10~Santa Fe~NM 87501~USA tel: 505 983 8956

Setropa Seeds~ Troelstralaan 4~1272 JZ Huizen~HOLLAND

Sutton and Sons,(INDIA) Pvt. Ltd.~PO Box 9207~Calcutta 700 071~INDIA~tel: 91 3329 0472
AGRICULTURAL MECHANIZATION

For many years the work of Leaf For Life has been very focused on teaching small groups of people, usually women, in tropical countries to make and use leaf concentrate in order to improve the nutrition and health of their families. It is worth remembering, however, that our search for means of producing and distributing leaf concentrate often leads to secondary benefits that may have lasting value for the communities we work with.

In Nicaragua, for example, we are trying to learn how to grow abundant cowpea foliage for leaf concentrate. Like much of the developing world, Nicaragua's agriculture has been shaped by centuries of colonial domination. There is a highly mechanized export sector that uses very expensive equipment to produce sugar, bananas, coffee and cotton. Then there is the subsistence or small farm sector where peasants try to coax enough food for their families with a machete and maybe a hoe. Between the $50,000 tractors and the $4 machete little is available in the way of labor saving agricultural tools. Out of necessity Leaf For Life has become involved in the introduction of appropriate scale agricultural tools.

One of the most promising of these tools is a simple wheel seeder that costs about $75. We introduced these because they enable us to plant cowpeas more accurately and more quickly. They give much more evenly planted rows which has eliminated both overplanting, which wastes valuable seed, and underplanting, which leads to low yields. As the farmer pushes the seeder along it opens a row to the depth we select, drops in seeds at the frequency we chose, and covers the seed with dirt. At the same time it is marking the next row at the distance we chose.

Keeping the rows free from weeds that compete with the cowpeas is another chore that we've had to address. Typically small farmers use either a machete to hack the weeds while bent over in the hot tropical sun or chop the weeds out with a heavy hoe. Both methods are extremely tiring and time consuming. Weeding needs to be done frequently or tough perennial weed grasses take hold and the yield of the crops drops sharply from their competition. We are testing two different types of wheel hoes that cost between $50 and $65. These tools allow the peasant to stand upright and walk quickly down the rows rolling a 20 cm (8") slicing hoe through the weeds. The wheel cultivator is so much easier and faster to use that workers are encouraged to stay ahead of the tough weeds with frequent shallow weeding. With slight modifications we can adjust the wheel seeder to lay out rows that perfectly match the wheel cultivators. Earthway, a US. based company
produces both seeders and wheel hoes; Coles Planet Jr. is a more expensive US. built wheel seeder. Both are available through Peaceful Valley Farm Supply.

Normally beans in Nicaragua are planted in rows 32-36" apart. This is tied to the space needed to cultivate with oxen. We are testing a system of planting beans in rows 16" apart with the wheel seeder and cultivating them with the wheel hoe. When they get too crowded we harvest every other row to make leaf concentrate. This system could produce far more nutrients per acre with less work. By having an extra row of beans between the wide rows, weeding would be easier, the soil would be improved and the land would yield LC and fiber for animals as well as beans.

Preparing small plots of land for planting is another job that plagues the Nicaraguan peasant. Often they contract wealthier farmers to prepare land with tractors. But because they have small parcels to plow they frequently have to wait until after the optimal planting time when the tractors are less busy. The big tractors require a substantial area at the end of the rows in which to turn. This means much of the land in small plots is left unprepared. We have partially resolved this problem in our small cowpea patches by using gasoline powered roto-tillers or rotary tiller.

We have used a 5 horsepower tiller that costs about $400 and are bringing in an 8 HP and a 14 HP tiller that costs about $1000 and $2500. These are more expensive tools, but still cost far less than the full size tractors. The largest of these is a BCS Italian made walking tractor. It is an amazingly versatile agricultural tool, that is becoming quite popular in parts of Latin America. It can prepare small parcels of land quickly for seeds and cultivate weeds. In addition a sickle-bar mower can be attached that enables one to quickly harvest forage crops at an even height. Attachments allow this tool to be used to chop or grind crops for animal feed, pump water, and even haul up to a quarter ton on a cart it can pull behind.
SOME GENERAL SUGGESTIONS
FOR GROWING LEAF CONCENTRATE CROPS

Information
- In most areas the farmers and gardeners who successfully grow traditional leaf crops are the best source of information on growing them.

- Try to make connections in the forage or horticulture departments of the nearest college level agricultural school. They can be very helpful in identifying local pests, suggesting varieties that have done well in the area, etc. Use the library.

- Try to find out the scientific name for any serious weed, insect pest, nematode or disease. Also scientific names for any local leaf crops that are of interest. This will enable distant workers to help find solutions or to provide useful information. Increasingly, we will be able to use high speed computer searches to find information quickly.

Water
- The most common limiting factor in leaf crop production is an inadequate or uneven supply of water to the plants. Lush leaf crops require a lot of water. Don't begin a leaf concentrate operation unless you can supply your leaf crops enough water for good growth. Most leaf crops thrive with 2 - 4 cm of water per week throughout their growing season. Once established, plants prefer a thorough soaking every week to ten days over a light sprinkle more frequently. Some plants, like cowpeas, are very sensitive to flooding, so overwatering can be as harmful as under watering.

- It may be more economical to produce more leaf concentrate than needed during the rainy season and preserve it for the dry season, than to try to irrigate crops through the dry season to maintain year round production. This can be a critical economic decision for a leaf concentrate project. It needs to be carefully thought out. Our experience with irrigation systems in developing countries has not been very positive. Often the capacity of the pumps or of the well or storage tanks is overestimated. Ditches may be clogged with water weeds that need to be cleaned out, or they may leak more water than reaches the plants. An irrigation failure during the dry season can mean a complete crop loss. Irrigation systems that are not carefully designed to provide adequate drainage of the added water can lead to salinization of the soil and a serious loss of soil structure. This is a very serious problem affecting irrigated farming.

- Always it costs more in effort or money or both to grow crops with irrigation than with rainfall. Usually you can produce much more crop if you can control the amount of water reaching the plants. Also plants frequently will perform better in dry season with irrigation than during a rainy season because of greater sunshine and fewer problems with molds, fungi, and viruses. Try to calculate the additional costs of the irrigation against its value, and against the additional costs of preserving leaf concentrate and leaving your workshop and workers idle through the dry season.
- Many plants respond well to irrigation directly after leaf harvests.

**Soil**
- Non-leguminous leaf crops are heavy nitrogen feeders. They will yield better with an application of manure, urea, ammonium sulfate, or other nitrogen fertilizer. Some leguminous crops will respond well to light feedings of nitrogen, but others like Clitoria may experience reduced forage yield.

- The value of the nitrogen added to the soil from leguminous leaf concentrate crops should be considered. We estimate that in Nicaragua $25-35 US per hectare can be saved by growing cowpeas for leaf concentrate and incorporating the fiber, then switching to corn production the following year.

- Leguminous leaf crops are usually heavy phosphorus feeders and will respond well to added phosphorus. This element is frequently deficient in tropical soil and often is the first factor limiting yields. PHOSPHORUS can improve yield of protein and biomass from legumes significantly even at 25-30 kg per hectare.

- Have your soil analyzed if that service is available at low cost and follow the fertilizer and lime recommendations if possible.

- If the soil structure or fertility is poor the residual fiber and whey can be incorporated into the soil to improve it. Low organic matter in the soil can lead to many problems including waterlogging, poor utilization of phosphorus, and poor aeration of crop roots. Manure and crop residues help maintain organic matter in the soil. It is important that carbon rich residues, such as straw, sawdust, or sugar cane bagasse be mixed with nitrogen rich sources like manure and leguminous crop residues. The addition of large quantities of carbon rich material can devastate crops until the soil microorganisms regain a soil balance. Building up soil organic matter is a long term undertaking, and it is impossible to do it adequately in one year or less.

**Planting**
- Seeds should be planted closer together than they are normally. For crops like cowpeas, or lablab that are normally grown for their seeds, it pays to plant at twice the normally density for maximum forage yield. Denser planting is not normally warranted for perennial legumes like alfalfa and pueraria.

- Plant seeds carefully. Planting too deeply is the most common cause of poor germination. If the seeds are carefully spaced in the rows and the rows are straight, the work of weeding will be much easier, and you won't need to thin the plants. When seeds are planted very quickly there is a tendency to have blank stretches and clumps of plants that are too close to each other. Both of these reduce yield.

- Inoculate legume seeds with commercial inoculant if available or with soil from a successful field of the same legume, unless the same crop has been grown on this land.
within the past three years. For some crops like Clitoria, inoculated plants will produce 25% more foliage, as well as fixing far more nitrogen from the air.

- Leaf crops can often be grown between two rows of another crop, then cut when their leaves begin touching the other crop. This can reduce weed problems and increases the productivity of the land.

**Weeds**

- It is especially important to control weed growth when leaf crop is young and just after leaf harvest. Keeping weeds down until the leaf crop is well established is especially important with perennial legumes, that tend to be a bit slower than annuals getting started. While a few weeds will usually have little effect on LC yield or quality, heavy weeds will compete strongly with your leaf crop for water, nutrients, space, and sunlight and the LC yield per hectare can be drastically reduced.

- Annual weeds are usually best controlled by cultivation, and perennial weeds can often be controlled by repeated cultivation as well. In small patches hand hoeing is often effective. A study in India gave the top rating to a long handled push-pull hoe with a 15-20 cm (6-8") serrated blade set at 70° to the handle. This was considered four times faster than pulling the weeds by hand.

- By far the worst weed problem we've encountered in Nicaragua has been Cyperuses, grasslike perennials in the nutedge family. They are extremely difficult to get rid of because of their extensive underground roots system. **The two essentials to controlling nutedges by attrition are to cultivate it before they have 5-6 leaves, at which point they begin producing tubers; and to keep them shaded by other plants as completely as possible.** They don't compete well in the shade and density of the Cyperus tubers and rhizomes can be gradually reduced until it is not a serious problem. Cyperus tubers can survive up to 4 years in dry soils.

- When the ground is not too wet, a high wheel hand cultivator fitted with a slicing hoe can be pushed quickly through the rows cutting of the Cyperus just below the ground. Where this had been done once every two weeks, the Cyperus was already large enough to be difficult to cut through and already forming new tubers. Running the wheel hoe through rows just wide enough for it to pass once a week should help keep the Cyperus from being able to photosynthesize and thus from being able to build up the reserves of carbohydrates in its root system that make it so hard to eradicate. Perennial weed grass, like Imperata, can be treated in much the same way as Cyperus.

- There are also wheel hoes and other simple cultivators that are set up to be drawn by animals. In general, draft animals supply more power than humans and greater flexibility than tractors. An ox typically delivers from 0.5 -0.75 horsepower, while a human worker rarely has a sustained output of over 0.1 horsepower.

- We do not usually recommend the use of herbicides to control weeds. They can be an expensive, usually imported habit. Poisoning of farm workers, contamination of ground
water, and accidentally killing desirable plants with herbicide is common, especially where workers cannot read warning labels. Where severe infestation of perennial grasses or sedges prevents adequate growth of leaf crops, it may be necessary to use herbicides to gain control initially. If herbicides are needed continually to maintain normal leaf crop yields, you should consider changing the leaf crop to one that can compete better with the weeds, or changing the cultivation schedule to one of frequent shallow weedicings until the grasses are weakened.

- Glyphosate (Round-Up) herbicide is probably the easiest and least expensive means of achieving control over perennial nutsedges and grasses. We used glyphosate to control the Cyperus for about 3 months before reinestation. The timing of the application of this herbicide is critical to its success. It should be applied when the Cyperus is about 20 cm high and growing rapidly. Workers at CATIE in Costa Rica suggested an application rate of 2 liters per hectare, with 700 ml mixed with 25 liters of water and delivered through very fine (80001-80005) low volume nozzles. Glyphosate is a fairly safe chemical in terms of acute toxicity to mammals with an LD 50 of 4320 mg/kg (this is the dosage that kills 50% of laboratory mice), compared with 2,4-D, for example, which has an LD 50 of 375 mg/kg. Glyphosate is a skin and eye irritant and care should be taken in mixing and handling it.

- Some crops can be used to smother weeds effectively. Closely planted sweet potato vines have been used for this purpose. Velvet beans, kudzu, and desmodium are examples of leguminous crops sometimes planted to smother weeds. These have the advantage of fixing nitrogen and can leave the soil enriched as well as relatively weed free. This technique takes far more time than spraying herbicide.

- Another technique for deterring persistent weeds is called “solarizing”. It is useful only for relatively small patches. The soil is tilled or plowed then wetted, then covered with a thin (2 mil) clear or black plastic sheet for 2 to 3 weeks. Clear plastic has been recommended more frequently, but recent tests indicate black plastic may be slightly more effective. Ultraviolet resistant polyethylene will hold up much longer under the tropical sun, but is more expensive and more difficult to find in most countries. In tropical climates the temperature will rise quickly and most grasses will be effectively killed. Many of the weed seeds under the plastic will also be killed. Nematodes and Pythium (the organisms that cause damping off) will also be killed. Perennial weeds with tubers, rhizhomes, or stolons below 10 cm (4”), such as Cyperus will usually recover from solarizing, though they will be weakened.

- Geese have been used to control weeds successfully in some locations. They are especially fond of young grasses and cyperus. About 10 geese per hectare is usually recommended. They have to be enclosed and provided with water and a small amount of additional food. If there is not

Temperature required to destroy pests

<table>
<thead>
<tr>
<th>PESTS</th>
<th>TEMPERATURE</th>
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<tbody>
<tr>
<td>Cyperus</td>
<td>4320 mg/kg</td>
</tr>
<tr>
<td>2,4-D</td>
<td>375 mg/kg</td>
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<tr>
<td>Glyphosate</td>
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### REQUIRED FOR 30 MINUTES

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<th>°C</th>
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<tr>
<td>Nematodes</td>
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<td>51</td>
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<tr>
<td>Damping Off (Pythium)</td>
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<td>55</td>
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<tr>
<td>Most Pathogenic Bacteria and Fungi</td>
<td>150</td>
<td>66</td>
</tr>
<tr>
<td>Most Soil Insects and Some Viruses</td>
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<td>73</td>
</tr>
<tr>
<td>Most Weed Seeds</td>
<td>180</td>
<td>83</td>
</tr>
<tr>
<td>Resistant Weed Seeds and Viruses</td>
<td>212</td>
<td>100</td>
</tr>
</tbody>
</table>

### Pests

- Avoid insecticides if possible. If not use low toxicity ones like neem, rotenone, BT (Bacillus thurengensis) saboradilla or pyrethroids. Wait at least 15 days to process leaves after spraying and wash the leaves especially well. Try safe insect repellents, such as garlic, onion, chilies, or tobacco soaked for two days in water. Then spray this water on the plants, after straining it. If slight insect damage affects appearance of leaves, as they will soon be ground to a pulp anyway.

- Neem (Azadirachta indica) is a tree from India that has been spread throughout most of the tropics. The seeds from the Neem tree can be ground in water to make an insecticide that is safe for mammals, doesn't persist in the environment, and can be easily produced locally, avoiding the cost and dependency on imported insecticides. It is effective in controlling grasshoppers, beetles, aphids, and caterpillars. Neem extract acts both as an insecticide and as a repellent. It doesn't kill instantly, as some synthetic insecticides do nor does it have as long lasting an effect. So it must be used as early as possible after an insect infestation is suspected and it may need to be applied more than once to maintain control. Neem leaves also have some insecticidal properties, though not as strong as the seeds. They are sometimes packed with beans or other seeds to repel storage insects. The wood from neem is very resistant to termite damage.

- If possible avoid walking through leguminous crops when they are wet from rain or dew. This is one of the main ways that viruses are transmitted. This is not always possible because it is advantageous to harvest leaf crop early in the morning when dew may still be on the leaves.
- Domestic animals belonging to neighbors could be the biggest pests of all. Cows, horses and pigs can damage a leaf crop quickly. Chickens can scratch up new seeds. Fencing in your crop can be a major additional expense if you are working in an area where livestock is roaming freely. Unscrupulous farmers may encourage their livestock to feed on your leaf crops to reduce their feed bill. This is normally a serious matter in agricultural societies, and the offending farmer will often be held liable for your losses.

**Harvest**
- Try to have fresh leaves year round by either adjusting a harvest schedule or by timing the planting of more than one crop. This requires considerable forethought and experience.

- Harvest the plant high enough to allow for rapid regrowth. For example, cowpeas cut at 20 cm above the ground will regrow quickly but those cut at 5 cm will regrow slowly if at all.

**INTERCROPPING**

Intercropping is the growing of two crops in the same field at the same time. It is one of the oldest agricultural practices known. An intercrop normally produces greater total yield than the two crops grown separately. So two hectares of corn and cowpeas intercropped will usually produce about 30% more than one hectare of corn and one hectare of cowpeas. Some plant combinations make more productive intercrops than others. The intercropping of a nitrogen fixing leguminous crop with a grain or other heavy nitrogen feeder like bananas is a common practice. Plants that are tolerant to shading are often well suited to intercropping with tree crops or tall plants like maize. Among tropical forage legumes, Desmodium intortum stands out for high productivity in moderate shade, followed by Pueraria phaseoloides, and Centrosema pubescens.

These are very important in developing countries where yields are often limited because farmers can't afford to buy nitrogen fertilizer, and agricultural soils are often depleted by grain crops. Farmers are usually primarily concerned with the main crop yield. If that holds up and there is either soil improvement, lowered fertilizer costs, or additional food products (ie. beans or LC), the farmer is likely to continue intercropping. If there is a significant decline in the main crop intercropping is unlikely to be continued, even if there are other advantages.

Leaf for Life is studying various intercropping systems using cowpeas and other crops that are suitable for leaf concentrate processing. Cowpeas are the ultimate intercrop plant. Over 90% of cowpeas grown in Africa are grown in intercrop systems. In Nicaragua the intercropping of 4 rows of cowpeas between rows of bananas and plantains has shown a lot of promise. Since the weeds need to be cut from between the banana rows anyway, it makes sense to use that space for a nitrogen fixing crop. The cowpea leaves are processed into leaf concentrate for child nutrition programs and the fiber and whey returned to the banana plants.
USING LEAF CONCENTRATE BYPRODUCTS

Leaf concentrate has been discussed at length in this manual, but what about the fiber and the whey that represent over 90% of the weight of the original leaf crop? When any fresh green leaf crop is processed into leaf concentrate three products are produced. The leaf concentrate, the residual fiber, and the residual liquid or "whey". 100 kg of leaf crop at 80% moisture content should produce about:

- 5 -7 kg leaf concentrate at 60% moisture
- 44 kg fiber at 70% moisture
- 50 kg "whey" at 94% moisture (it may have an even higher moisture content from the dew or wash water left on the leaf surface before it was pulped).

Another way of viewing this breakdown of leaves is to figure that 100 kg of fresh leaf crop at 80% moisture should produce roughly:

- 2 kg dry of LC
- 2 kg dry weight of "whey"
- 16 kg dry weight of fiber
- 80 kg water

RUMINANT FEED

When figured on a dry weight basis, the fiber left over from leaf concentrate processing has approximately the same feeding value to animals as unprocessed fresh leaf crop. Although much of the protein has been removed in the leaf concentrate, the residual fiber still retains adequate protein good cattle feed. Grinding the leaves up well in the process means that the fiber has far more surface area than the original leaf crop and this enables the cow's digestive system to extract nutrients more effectively. Because fresh alfalfa and other leaf crops are usually around 20% dry matter, while the residual fiber is around 30% dry matter; the fiber has about 1 1/2 times the feeding value, per kilogram, as the leaves that it was made from.

100 kg fresh leaf crop = 80 kg water + 20 kg dry matter
50 kg of fiber = 35 kg water + 15 kg dry matter.

In practice the moisture of forage crops varies from about 75-90 %.
If we assume a daily ration of 2 kg dry matter for every 100 kg cow weight, this 50 kg of fiber will feed 2 1/2 300 kg cows. The 100 kg of unprocessed leaf crop would feed 3 1/3 cows of the same weight.

The palatability of leaf concentrate residual fiber is generally quite good if it is fed fresh or well dried. It ferments readily if left in a pile, especially in hot tropical weather, and quickly loses palatability. We have found that cows like it better than do goats or rabbits but all will usually eat it unless they have been very well fed recently. It is a good idea to introduce the fiber gradually in the diet of animals and to make sure they get other feed as well to assure a sufficiently varied diet.

**SILAGE**

Besides drying the fiber for later use it can be preserved by storing it in a silo. This as a technique commonly used in many areas for preserving green cattle feed through limiting the amount of air that comes in contact with the green crop. The action of the anaerobic (living without air) bacteria alters the acidity of the green feed and makes it more stable. Work is being done in India with combining leaf concentrate fiber with bagasse (residue from sugar cane milling) and straw that has been partially broken down with ammonia from urea. This could become a very inexpensive cattle feed and an excellent way to utilize sugar cane waste that is discarded in many tropical locations.

Another technique showing even greater promise is described below:

1. Mix together about 215 liters of leaf concentrate whey, 100 kg of sugar cane bagasse (c. 10 -15% moisture), and 3 kg urea.

2. Pack very tightly into plastic drums or heavy walled plastic bags. This mixture must be well tamped down and well sealed to exclude as much air as possible.

3. Mix together 300 kg fresh leaf concentrate fiber (c.70 % moisture) and 3 kg urea.

4. Pack very tightly into plastic drums or heavy walled plastic bags. This mixture must be well tamped down and well sealed to exclude as much air as possible.

5. Leave both for two to three weeks to enable the anaerobic bacteria to break down the tough fibers.

6. Mix the two silages together and add a small amount of crude molasses and crushed limestone if they are available.

7. This mixed silage is now ready to feed. It will have about the same feed value per kg as fresh alfalfa, and it is an excellent way to make use of the nutrients in the leaf concentrate whey and fiber, so that no part of the leaf crop is lost.
SOIL IMPROVEMENT

In locations where the structure or fertility of the soil is low, the residual fiber can be worked back into the soil with a hoe, roto-tiller or plow to improve it. Research in India shows wheat yields were greatly increased when they were planted 30-40 days after a green manure crop of Sesbania sesban or Crotalaria juncea was tilled in. They also found that they could remove some of the nitrogen in the green manure crop as LC and still improve the wheat yields. The wheat yield per kilogram of nitrogen supplied was greater with the LC fiber than with the whole green manure plants tilled in. Because the nitrogen which is recovered in the LC is in a form that tropical soil bacteria quickly attack, most of this nitrogen may be lost to the air before plant roots can use it.

Incorporating leaf concentrate fiber can supply nitrogen and improve the structure of the soil by adding organic matter. Leaving green manure crop residues on top of the soil has nearly the same impact on nitrogen availability as tilling the crop in, and it requires less time and energy and will protect the soil against erosion better than the tilled in residues. Well structured soils rich in organic matter absorb and retain water far more efficiently than soils maintained only with soluble synthetic fertilizers. This means less flooding and less drought damage. It also makes for more efficient use of rains and reduces the risk of salinization from poor drainage in irrigated farmland.

Green manured soils also make better use of phosphorus in the soil by encouraging mycorrhizal fungus. The mycorrhizae aid plant roots in absorbing phosphorus that is often present in tropical soils in forms that are difficult to utilize. Studies at ICRISAT in India showed that chickpeas release mallic acid from their roots that lower soil pH in the root zone and make phosphorus that is bound with calcium more available to plants. Pigeonpeas, on the other hand release picidic acid, which has a similar effect of freeing phosphorus bound with iron. It is quite likely that other legumes have similar beneficial impacts on phosphorus availability.

Preliminary studies have shown that cowpea forage added to soil lowers the acidity and reduces aluminum toxicity more effectively than lime.* Many tropical soils are very acidic and aluminum toxicity is increasingly a limiting factor in crop yields. Spreading crushed lime on fields can be very expensive, especially where transportation is a major problem.


MUSHROOMS

Work underway in India has shown the potential of using leaf concentrate residual fiber as a base for mushroom production. A mixture of one half straw and one half residual fiber was used as a substrate for raising Pleurotus ostreatus (Oyster mushroom). The yield using this mixture was roughly twice what is produced by using straw alone. Oyster mushrooms are a high priced delicacy in many markets. There are several closely related
species of edible Pleurotus mushrooms. All of them are efficient at breaking down the tough lignin fiber in straw.

Pleurotus will convert 100 kg of straw into approximately 10 kg of mushroom; 70 kg of water and carbon dioxide; and 20 kg of spent compost. The spent compost is useful as a cattle feed component, because about 80% of the tough fiber in the straw has been broken down into substances that are more easily digestible by ruminants. A tremendous amount of straw is burned in the field each year in the tropics in order to prepare the fields for the following crop. The burning of straw in the field is one of the world's worst sources of air pollution and the loss of organic matter speeds up the degradation of tropical agricultural soils. The commercial value of straw is often too low to justify the labor involved in collecting and composting it to use to maintain soil fertility. If 10% of the weight of the straw could be converted to high value mushrooms and 20% to cattle feed, there could be a great incentive for farmers not to burn their straw in the fields. The spent compost from Pleurotus culture has also been used as a substitute for chicken manure in commercial plant nurseries in Puerto Rico.

Pleurotus has also been successfully grown on sugar cane bagasse, sawdust and cotton waste. Both the yield of mushrooms and the value of the spent compost are enhanced when the mushrooms are grown on a substrate richer in protein than straw. The leftover fiber from leaf concentrate production has enough nitrogen to enrich at least an equal weight of straw. The 50:50 ratio of straw to leaf concentrate residual fiber should make the Pleurotus culture even more attractive as an alternative to burning fields. This is an area that clearly warrants more practical investigation. (see Technical Guide for Growing Mushrooms in the Tropics, listed in Appendix).

**BIO-GAS**

Another possible means of using both the fiber and the "whey" is to incorporate them into a bio-gas or methane production scheme. Bio-gas can be economically produced in many locations where there is a good supply of manure and other organic wastes. The process which also employs anaerobic bacteria, converts part of the waste to gas that can be used to cook with much the same as propane. The effluent, or slurry left over after bio-gas has been produced from organic wastes, is rich in nitrogen and is useful for improving the structure and fertility of soils. In Nicaragua, part of the residual fiber from leaf concentrate was used to make bio-gas, which in turn was used to cook lunch at the cafeteria of the International School of Agriculture. Bio-gas production can be quite involved and many projects have concluded that it is not economically feasible in their location. However, in some countries, notably China and India, low cost bio-gas units are available and have had some popularity.

It may be possible to use bio-gas to heat the leaf juice in LC projects. A group processing 500 kg of leaf crop per day would produce roughly enough fiber to feed 7 cows and it would need the manure from 9 cows to produce enough bio-gas to the 250 liters of leaf
juice to boiling. Only where cooking fuel is very scarce or expensive is bio-gas worth serious consideration.

"WHEY"

We often refer to the clear brown residual liquid as "whey" because of its similarity to the whey that is a by-product of cheese making. Heating the leaf juice is a process quite similar to making simple cheese from milk. In both cases a liquid is coagulated forming curds that contain most of the protein and oils and a clear tea colored liquid. This "whey" is rich enough in nitrogen and potassium to be of some value as a fertilizer. It is deficient in phosphorus, however. The fertilizer value of the "whey" is limited by the fact that it is at least 94% water. This means it must be used very near the leaf concentrate processing site to justify the costs of transporting it to the fields. This problem is even greater when the leaf concentrate is made by the blender method because the nitrogen and potassium in the "whey" are further diluted by the extra water used in blending the leaves.

The amount of water required by rapidly growing plants is often underestimated. 20-30 liters of water or "whey" are needed each week to supply each square meter of tropical land in maximum leaf production. The "whey" produced as a by-product of leaf concentrate will not be nearly enough to irrigate the land area from which the leaves were harvested. High concentrations of "whey" may damage some tender seedlings. Diluted "whey", as in that from blender processed leaf concentrate, is safe for plants. It is best used for high value crops near the processing site. Obviously, it is a sound idea to wait until the "whey" is completely cooled before pouring it on plants.

Leaf concentrate "whey" is not acceptable in the human diet because of concentrations of nitrates, oxalic acid, and other anti-nutrients. While it has been remixed with the fiber for cattle fodder with good results, watering pigs with "whey" has led to kidney problems over time. Large scale LC operation could possibly justify the expense of evaporating the whey until it was a thick molasses like liquid that could be remixed with the fiber and increase the available nitrogen in ruminant feeds.

It has been suggested frequently that this "whey" could serve as a source of nutrients for growing various beneficial microorganisms like yeast or penicillin. This application requires highly controlled environments to prevent contamination with unwanted microorganisms. These conditions are rarely available in developing countries except in major cities. A project initiated by Find Your Feet in Ghana had some success in producing ethyl alcohol by adding some sugar to the "whey", fermenting this liquid, then distilling it. Production of ethyl alcohol can become very complicated because of government controls or tax policies, or the potential for increasing abusive alcohol consumption.

An interesting use for LC "whey" was suggested by Dr. Ham Bruhn at the University of Wisconsin. He says that pouring the "whey" over the ground will bring angle worms to
the surface. This may be a useful trick for fishermen, or those raising worms for soil improvement.

**SEEDS AND ROOTS**

Immature pods from cowpeas or other types of peas and beans are another potential byproduct of leaf concentrate. Yield of leaf concentrate per kg of leaf crop will decline when the crop begins to flower, but we have found that good quality leaf concentrate can still be made from cowpea leaves after an initial harvest of immature pods. Despite careful planning, often times there will be crops that pass through the ideal stage before they are harvested for leaf concentrate processing. Because of this, there is a real advantage to crops like beans, cowpeas, lablab, or winged beans that have a commercially valuable seed that can be harvested and sold if the plants cannot all be processed for leaf concentrate before they mature.

There are several agricultural situations in which leaves used for making leaf curd would be the byproduct of some other commercially viable product. For example, cassava roots have a broad market but in many locations the leaves are without commercial value. Carefully timed harvesting of cassava leaves can actually increase the yield of edible roots significantly and the leaves could be made into leaf curd. Several vegetables, including cauliflower, broccoli, turnips, and beets have leaves that can be made into LC rather than discarded in the fields or at packing plants.

As with green manure crops and intercrops, it is important not to confuse the primary and secondary objectives of the farmer. If one can get a better yield of the primary product a farmer may be willing to try a new system. Farmers will rarely want to take a reduction in yield in their main crop or an increase in labor, for the sake of an output like leaf curd, whose value may be little known to them.
SECTION IV

ECONOMICS OF LEAF CONCENTRATE

You may know what a kilogram of beans costs, but what does a kilogram of leaf concentrate cost? This is a question that is as important as it is difficult to answer. The cost of supplying leaf concentrate can be calculated as a product like beans, or as a service provided, like health care. In either case, if leaf concentrate is to catch on, it needs to have some economic advantage over competing products or services.

One of the most important jobs of field workers at leaf concentrate programs is to perform ongoing economic analysis. This involves collecting information in quantifiable terms on as many aspects of the program as possible. You may want to start with the wholesale and retail prices of other nutritious foods available in the area. These would often include several types of meat, fish, seafood, cheese, eggs, dairy products, beans, and grains. Powdered milk and dry infant formulas are also useful prices. This will help you determine what the value of leaf concentrate is likely to be, which will in turn help set the price that you will be able to sell it for. There is never a product exactly equivalent to LC on the market so you have to make approximations. The chart on page 90 may be helpful in making value comparisons among nutritious foods. It is important to remember, though, that there is often a great difference between the nutritional value of LC and its perceived value by the local people. The perceived value is what they think it is worth and this will determine the demand for the product. One of the most difficult and important jobs of leaf concentrate workers is educating the population so that the perceived value of LC begins to reflect its nutritional value. When one is selling LC to institutions for nutritional support program the perceived value of the LC should be close to its nutritional value.

Next you will need to gather as much information as possible on the cost and availability of the raw material or leaf crop you will be using. How much will price vary during the year? How much will quality and moisture content vary over the year? Does the price include harvesting and transportation to the field? In some places forage crops, like alfalfa, are normally sold standing in the field. It will do little good to know that an area of alfalfa 3 meters wide by 75 meters long cost $8 US. You will need to calculate how many kg of leaf crop that is, and what it costs to cut it and haul it to the workshop.

After you have a good idea what leaf crop costs you need to gather information on labor costs. What do agricultural workers in the area normally receive for a day's work? How about supervisory workers? What will workers processing leaf concentrate need to earn to make it an attractive idea for them? This may involve some things other than hourly wage. Transportation costs are very important to workers. Will they have to pay for a bus ride or spend and hour walking to work? Fringe benefits are also important in many work situations. Some times workers would prefer earning a lower hourly rate at one job because it entitles them to health insurance or reduced cost child care, or gives them
access to subsidized housing. You need to ask a lot of questions to find out real wages. Sometimes people are reluctant to discuss their incomes, so you may need to work with a trusted local intermediary.

Once you have a good idea what the value of your product (LC) will be, and the costs of raw material and labor, you will need to find out as much as you can about the other costs that are required to produce and distribute the LC. These will include capital expenses and depreciation on capital equipment. Capital expenses generally refer to large purchases whose value is retained for a long period of time. This would include grinders, presses, stoves, cookpots, tables, and improvements to the workshop. Capital expenses are difficult to calculate for many LC projects because often some of the capital costs are donated. Projects that are social service programs may have equipment and other costs met by donation. This can lead to underestimating actual production costs. If $5000 is required to set up a project, the price of the LC should ideally reflect repaying a loan for $5000 plus a normal interest rate. Depreciation is the value lost to wear and tear on equipment. If a grinder costs $1000 and you expect it to need replacement after five years, it means that grinder is depreciating in value an average of $200 per year or about $17 per month. This is another production cost that should be figured in to the price charged for the LC.

Some of the other costs that you will typically encounter are rent on the workshop, electricity, fuel for heating juice, water, and cleaning supplies. Sometimes taxes or registration fees and licenses will need to be paid. There are usually expenses in marketing or distributing the LC that you make. These might include packaging supplies, salaries or commission for salespeople, transportation, free samples, and advertising.

Once you have gathered the basic economic information, you can begin analyzing it. It is often useful to calculate the total production cost of a kilogram of leaf concentrate. Then try to figure how much of that cost is attributable to raw material, labor, capital expenses, fuel, etc. By taking average monthly expenses and production you should be able to get some idea how much the electricity or gas or labor cost for each kilogram of LC. At this point you will be able to see where you should focus your cost cutting efforts. Successful enterprises will eventually eliminate most of their unnecessary costs, but they will start with reducing those costs that are greatest.

Below is a very simple budget broken down for a hypothetical small project, that may help clarify the process of making an economic analysis: * All figures are in US dollars.

**Expenses**

\[
\begin{align*}
\text{200 kg leaf crop per day} & \times \text{250 days of processing per year} \\
\text{Leaf Crop} & = 50,000 \text{ kg} \\
& \times $ .06 \text{ kg}
\end{align*}
\]
= $3,000 for leaf crop for the year

Transport of Leaf Crop $3 per day X 250 days $750

Labor $9 for 3 workers @ 1/2 day X 250 work days = $2,250 labor for one year

Equipment $2000 spread over 5 years = $400 per year

Gas 330
Electric 120
Cleaning Supplies 50
Miscellaneous 300
$800 per year

TOTAL ANNUAL EXPENSES = $7200

Income

Leaf 1000 kg dry LC Concentrate X $7.50 per kg (equivalent to about $3 per kg fresh LC) = $7500 per year

Fiber for Animal Feed 22,000 kg X $.04 per kg = $880 for one year

TOTAL GROSS ANNUAL INCOME = $8380

TOTAL NET ANNUAL INCOME = $1180

This analysis is partly based on several assumptions. One of the most important is that 100 kg of fresh leaf crop will yield 2 kg of dry LC. I've assigned a price of $.04 per kg for the fiber which is two-thirds the price of the leaf crop per kg. Many dairy farmers may think that the fiber should cost less than the crop because you have removed something of value, namely the leaf concentrate, from the forage crop. In fact, a kilo of the fiber has a feed value roughly 1½ times greater than a kilo of leaf crop, due mainly to the lower water
content of the fiber. It is very important that we are able to convince farmers of this fact. Again the difference between perceived value and nutritional value is critical. Using this hypothetical project we can calculate that it cost $7200 to produce 1000 kg of dry LC. This comes to $7.20 per kg (equivalent to about $2.50 per kg fresh LC). Or:

$3.00 for leaf crop  
.75 for transporting leaf crop  
2.25 for labor  
.40 for equipment  
.33 for gas  
.12 for electric  
.05 for cleaning supplies  
.30 for miscellaneous expenses  
$7.20 for 1 kg dry LC

From this one can see that, for example, cutting your electric bill in half would lower per kg costs to $7.14. Reducing crop cost by 15% on the other hand would lower costs to $6.75 per kg. What if you could improve the yield of LC by modifying the equipment and technique somewhat? Suppose you could get 2.5 kg per 100 kg of leaf crop by investing another $1000 in equipment. Then you could produce 1250 kg of dry LC for $7400 ($7200 + 200 extra depreciation each year for the additional $1000 of equipment). This would come out to $5.92 per kg. So increasing the yield is more likely to improve the economics of your project than reducing crop costs or electric consumption.

Cost Analysis from Bareilly, India

The information given below was gathered by Walt Bray for a leaf concentrate project in India. They should give a more concrete idea how this type of analysis can help. These relationships are specific to conditions in Bareilly, but some will apply generally to other leaf concentrate projects.

Basic assumptions: 500 kg of leaf crop at 83% moisture processed per day  
5% yield of 60% moisture LC  
215 kg of fiber sold at the same cost of leaf crop (on a dry matter basis)  
Labor = 4 workers + 1 supervisor  
Equipment cost = $1600 US  
Calculated production cost = Rs 15.6 per kg fresh LC ($0.46 US)*  
* 1 Indian Rupee = $0.031 US

$0.031 US

General breakdown of costs

<table>
<thead>
<tr>
<th></th>
<th>with fiber sales</th>
<th>without fiber sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Crop</td>
<td>12.5% of total</td>
<td>37% of total</td>
</tr>
<tr>
<td>Labor</td>
<td>14.1%</td>
<td>29.6%</td>
</tr>
<tr>
<td>Category</td>
<td>Calculated Production Cost</td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>----------------------------</td>
<td></td>
</tr>
<tr>
<td>Supervisor</td>
<td>17.1%</td>
<td></td>
</tr>
<tr>
<td>Power, and fuel</td>
<td>13.1%</td>
<td></td>
</tr>
<tr>
<td>Maintenance and depreciation</td>
<td>16.2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.3%</td>
<td></td>
</tr>
<tr>
<td>9.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.7%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Effect of LC Yield on calculated production cost:**

- 3% yield = Rs 26/kg, increase of 66.7%
- 4% yield = Rs 19.5/kg, increase of 25%
- 5% yield = Rs 15.6/kg
- 6% yield = Rs 13/kg, decrease of 16.7%

**Effect of fiber sales on calculated production cost:**

- Sale of fiber = Rs 15.6/kg
- No sale of fiber = Rs 21.6/kg, increase of 39%

**Effect of daily processing rate on calculated production cost:**

- 250 kg leaf crop/day = Rs 20.6/kg, increase of 32%
- 500 kg leaf crop/day = Rs 15.6/kg
- 600 kg leaf crop/day = Rs 13.5/kg, decrease of 13%

**Effect of leaf crop cost on calculated production cost:**

- Rs 0.4/kg = Rs 15.6/kg
- Rs 0.8/kg = Rs 17.5/kg, increase of 12.5%
- Rs 1.2/kg = Rs 19.5/kg, increase of 25%

**Effect of leaf crop cost on calculated production cost (with no sale of fiber):**

- Rs 0.4/kg = Rs 21.6/kg, increase of 39%
- Rs 0.8/kg = Rs 29.6/kg, increase of 90%
- Rs 1.2/kg = Rs 37.6/kg, increase of 141%

**Effect of amount of labor on calculated production cost:**

- 3 workers + supervisor = Rs 14/kg, decrease of 10%
- 4 workers + supervisor = Rs 15.6/kg

**Effect of capital equipment costs on calculated production cost:**

- $1500 US = Rs 15.6/kg
- $3000 US = Rs 18.1/kg, increase of 16%

**Effect of bio-gas unit on calculated production cost:**

- No purchased fuel due to bio-gas unit = Rs 14.9/kg, decrease of 4.6%
- All fuel purchased = Rs 15.6/kg
Factors Affecting Dry Weight Value of Certain Nutritious Foods

<table>
<thead>
<tr>
<th></th>
<th>% of food that is normally edible</th>
<th>% moisture content</th>
<th>price multiplier for edible portion on dry weight basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat (beef, mutton, goat, pork)</td>
<td>82.5%</td>
<td>60%</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>52%</td>
<td>67%</td>
<td>5.8</td>
</tr>
<tr>
<td>Fish (non-fatty)</td>
<td>45%</td>
<td>78%</td>
<td>10</td>
</tr>
<tr>
<td>Eggs*</td>
<td>89%</td>
<td>74%</td>
<td>4.3</td>
</tr>
<tr>
<td>Milk (fresh)</td>
<td>100%</td>
<td>88%</td>
<td>8.3</td>
</tr>
<tr>
<td>Milk (powdered)</td>
<td>100%</td>
<td>2%</td>
<td>1</td>
</tr>
<tr>
<td>Cheese (medium soft)</td>
<td>100%</td>
<td>42%</td>
<td>1.7</td>
</tr>
<tr>
<td>Beans (whole dry)</td>
<td>90%</td>
<td>11%</td>
<td>1.3</td>
</tr>
<tr>
<td>Leaf Concentrate (dry)</td>
<td>100%</td>
<td>10%</td>
<td>1.1</td>
</tr>
</tbody>
</table>

* Figure 22 eggs per kilogram.

This chart will give you an idea of the true nutritional value of some common foods that are otherwise purchased as protein sources. Powdered milk selling for $10 per kg is about the same price as fish selling for $1 per kg, or chicken selling for $5.80 per kg once you have figured in the waste and water content. Of course, these foods vary somewhat in their actual nutritional composition, so exact comparison cannot be made. But it is easy to see the importance of calculating in waste and moisture content.

Much of the basic economic analysis for leaf concentrate projects should ideally be carried out before the sites are selected. The more information of this type we have at the start of the project, the greater the likelihood of achieving financial self-sufficiency. There is a series of questions in the section of this manual entitled "Considerations for Setting Up Leaf Concentrate Projects". It is a very good idea to get an answer to as many of these questions as possible before the decision to begin LC production. Even if this is done thoroughly, however, you will need to periodically update your economic analysis to reflect changes in local prices and labor costs.

Up to this point all of the economic analysis has been based on selling LC as a commodity. Another way of looking at leaf concentrate economics is to consider the
value of providing nutritional support for malnourished children. This is clearly a service to the community and to the society in general. From the viewpoint of the community or the general society, a well designed program of nutritional support for malnourished children makes tremendous economic sense. Children who are brought up to normal nutritional levels will become far more productive adults than those allowed to remain malnourished. They will require less expensive medical care, and make much better use of the educational resources your community offers children.

From this perspective our analysis would look somewhat different. The same hypothetical project described on page 87 could supply 670 malnourished children with 6 grams of dry leaf concentrate 5 days a week. If we assume the same production costs of $7200, and the same income from fiber sales of $880; then it will cost $6320 to provide 670 children with leaf concentrate. This comes out to under $10 per child per year, which is an investment many government and international agencies would consider very sound. Of course, there are other costs to providing the nutritional support, but this is often a more attractive way to market leaf concentrate, at least initially, than as a commodity in the open market.

Whether you are offering the leaf concentrate you produce as a product for sale or as a nutritional service, you will have to compete with others offering alternatives. You will need to know not only what meat and eggs and beans costs, but what food supplementation programs and hospital nutrition recuperation programs costs in your community. In either case, it pays to streamline production. If you can find less expensive leaf crop, or a way to improve yield of leaf concentrate, or less expensive machinery, or a better price for your fiber, you will have a more economic project.

**Economics of Very Small Scale Production**

Many times we are asked to help set up very small scale nutrition intervention programs. These programs are often designed to provide nutritional support for the children of one village. Frequently this is fewer than 50 children. The idea is that these programs would be very inexpensive to set up as they would use only hand operated pulpers, such as manual meat grinders, and presses. They would be very decentralized and, at least in theory, very sensitive to local conditions. They may be less encumbered by bureaucratic restraints and administrative overhead than larger programs. Despite these advantages, Leaf For Life does not advocate small programs that use hand operated leaf grinders.

The main reason for this is that a person using a relatively simple inexpensive electric or gasoline powered grinder can grind ten times as much leaf crop in an hour as a person grinding leaves by hand. Hand grinding of leaves is physically demanding as well as slow. Where people are affected by serious poverty and malnutrition, it is a dubious service to introduce an activity that will take up so much time and bodily. By the second hour the worker with the powered machine will likely produce times as much as the one with the hand powered grinder, and the latter is unlikely to be able to last even that long.
If the project uses volunteers, it must accept that the majority of this type of program suffers a drastic decline in volunteer participation after two or three months. If the workers are not being paid and cannot see obvious benefits to their families, they will typically begin arriving late for work and leaving early. Excuses will replace output, and the aggravation of keeping the volunteer labor force coordinated and enthusiastic will become a drain for most community leaders.

If a leaf concentrate program pays a worker to grind leaves, it cannot afford to pay one who uses a hand operated grinder. If the worker is paid according to production he makes perhaps one - tenth as much as the more productive worker with a powered grinder. Even after figuring in the lower capital cost of the manual equipment, he is unlikely to earn more than one - fifth as much as the other worker. If he is paid more than that the project is not getting good value for money. If a worker is willing to work for wages that low because of extreme poverty and lack of other economic opportunities, he or she is doomed to a cycle of poverty, because it will be impossible to provide for a family adequately on this income.

If we serve any purpose in introducing leaf concentrate technology to developing countries, it must be done in such a way that peasants can create more wealth from their labor than they are currently able to. People rightly expect "development" to lighten their work load and increase their productivity. This means power tools for physically demanding tasks.

**Economics of Very Large Scale Production**

At the opposite end of the spectrum are very large scale leaf concentrate operations. There have been several of these over the past twenty years. All have been in industrialized countries and all have used the leaf concentrate primarily for animal feed. The scale of these operations dwarfs the village scale programs established by Leaf for Life. By way of example, France Lucerne, a French firm that processes alfalfa, about 12,000 tons of dried leaf concentrate a year from three plants. The alfalfa comes from about 7000 hectares of alfalfa. They run from mid-April until mid-October at three locations. Each plant represents several million dollars in capital investment. The continuous process is under sophisticated computer control.

Because of their large volume and the advanced technology, France Lucerne can produce dried LC for far less per kilogram than any of the village programs can ever hope to achieve. As attractive as that is, there is a down side to the large scale operations. In the first place they require a great deal of capital that is rarely available in developing countries. They also require a large area dedicated to the leaf crop and a dependable system of transportation to deliver it to the processing plant within a couple of hours. Distributing 12,000 tons of dried LC would also be a daunting task in most developing countries. There is usually a shortage of the highly trained specialized technicians that are needed to run such a plant.
In the US a large plant was built by Atlantic Richfield Oil Company in El Centro, California. I was originally conceived to process up to 60 tons of alfalfa an hour. It was selling dried LC in a pelletized form mainly to the Japanese poultry industry. They used it because it made the skins of factory farmed chickens a more appealing golden color. It also gave the eggs from factory farm a richer looking yolk that customers prefer. When the Mexican peso was devalued in the early 1980's the price of Mexican marigold meal dropped sharply, and the Japanese began buying it rather than LC to color their eggs. The El Centro plant lost millions of dollars and closed. There are dangers from being too big as well as too small.

**MAKING THE BEST USE OF LEAF CONCENTRATE**

Leaf concentrate is an excellent food for everyone over 6 months of age, but in most programs production is limited and choices must be made as to where the leaf concentrate will do the most good. Below are some general guidelines on this subject.

- Younger children benefit more than older ones from the same amount of leaf concentrate. Children under 4 and especially those between 6 months and 2 years will show more improvement in health than school age children on a leaf concentrate program. We don't recommend giving children under 6 months leaf concentrate because their digestive systems are still developing and there is a greater likelihood of indigestion.

- Malnourished children benefit far more from feeding programs than children who have normal height and weight for their age. This is very important. Third degree malnutrition (defining degrees of malnutrition is discussed in the nutrition section of this manual) is a life threatening condition. These children should always be given top priority in any nutrition program. It is worth the effort required to go to their homes, talk to their parents, or do whatever is necessary to get leaf concentrate to these children. It could save their lives.

  Second degree malnutrition puts a child at great risk of serious health problems. These children are the next priority. Any nutrition program should try to identify and supplement the diet of all third and second degree malnourished children in the area being served by the program. It may be worthwhile to get two servings daily to third degree children. They should get 30 grams or two tablespoons of fresh leaf concentrate daily if possible. Second and first degree malnourished children should get at least 15 grams a day, preferably 20.

- Although weight-for-age records for children are sometimes misleading, it is important to maintain some kind of records on the growth of the children in your program. Many nutritionists feel that weight-for-height is a more accurate indication of nutritional status than weight-for-age. By periodically evaluating the nutritional status of the children in your program, you can get an idea how good a job you are doing. It may also
help you to know when a child can be taken off the program to make room for one who is more malnourished.

- It is usually more effective to enrich children's diet at a higher level for a shorter time than to give them a slight supplementation for a longer period. Thus it may be better to give 100 children 30 grams of leaf concentrate daily for 6 months then switch groups, than to give 200 children 15 grams daily for the entire year. Six months is about the minimum time for a nutrition program to have an impact on a child's health.

- Children showing any degree of night blindness should begin getting 30 grams per day immediately if possible. They should get a vitamin A capsule if they are available.

- Children recovering from injury or illness, especially diarrhea should get 30 grams a day, if possible, in bland foods such as pudding or noodles or soup.

- Children with anemia should get leaf concentrate lemonade or leaf concentrate combined with another source of vitamin C, like guavas, or with a small portion of meat or fish daily until the anemia is reversed. The presence of vitamin C or meat or fish in the same meal makes the iron from vegetable sources, like leaf concentrate, much more usable to the body. You can look under a child's eyelid (with very clean hands) and if the tissue is whitish or light pink rather than red, it is very likely that the child is anemic.

- After malnourished children, pregnant women should receive the highest priority in nutrition intervention programs. They should be offered 40-50 grams daily if possible because of their greater nutritional needs. Since anemia is extremely common among pregnant women, it is also advisable to include a source of vitamin C or small amount of meat or fish with their leaf concentrate. Special care should be taken to get their opinions on leaf concentrate dishes as pregnant women often have strong likes and dislikes for certain foods.

- Lactating or nursing mothers are usually the next highest priority for nutrition programs. They have a particular need for calcium and protein, both of which are well supplied by leaf concentrate.

- If there is an adequate supply of leaf concentrate, adults recovering from illness or injury should next be considered for your program, as should older women who are often troubled with osteoporosis, in which their bones become brittle from too little available calcium.

Two other issues come up frequently when considering how a community can make the best use of leaf concentrate or other nutritional resources. The first of these is the question of intestinal parasites. In many villages in developing countries a majority of the children suffer from intestinal parasites. Some people argue that it is pointless to offer a nutritional supplement because 'you are just feeding the worms'. They argue that the problem is first a medical one, then a sanitation one, and only then a nutritional one.
Others say that it does little good to get medicine to expel the worms, because if the living conditions aren't changed the children will be rapidly re-infested.

The problem with these approaches is that it is very expensive putting in good water systems and cleaning up other sources of parasite infestation. In many communities this is not likely to happen in the foreseeable future. Even the access to the medical care and the drugs used to expel worms is too expensive for a great many people.

While government and other agencies should be urged to begin taking these problems seriously enough to allocate adequate funds; hygiene and sanitation education are inexpensive and can be a part of every leaf concentrate project. Furthermore, studies show that only severe infestations of intestinal parasites affect the nutritional status of children. At the lower levels of parasite infestation that are most common in children, normal health and normal growth are possible with good nutrition. Children with more serious infestations should definitely be treated by local health workers familiar with these problems, if that is possible.

The second issue concerning the optimum use of leaf concentrate or other nutritious foods pivots on the relative merits of central feeding centers vs. feeding the children in their homes. Many health workers feel that the central feeding centers are the only way that you can be sure if the child is actually eating the food offered. They think that the food sent to the child's home is often shared with other family members and sometimes fed to animals.

On the other hand many malnourished children live far from the centers of town. Often the poorest people live the furthest from the resources offered by the town. Young children can't walk a long way on their own and their parents are often too busy with housework, caring for other children, or earning money, to carry them to the centers every day. Sometimes parents are ashamed to send children with no shoes or tattered clothes into the town's center. For these people a program that can deliver leaf concentrate in a preserved state once a week or once every two weeks may be a better option. With a program where the food is eaten at home it is extremely important that someone from the program checks in with the family frequently to encourage them to use the leaf concentrate effectively.

This is a big commitment of labor, and sometimes it is hard to find workers to hike back the muddy trails to these people's homes. Regardless of how it is done, some means needs to be found to reach the children who live on the outskirts of towns and villages or a nutrition program will fail to meet the needs of the community.
LEAF CONCENTRATE AND OLDER ADULTS
IN DEVELOPING COUNTRIES

In many societies elderly people are the fastest growing segment of the population. Antibiotics and improved medical care are allowing more people to live beyond the age of sixty even in developing countries where the general standard of living is very low. Older people need the same forty nutrients - carbohydrates, proteins, fats, vitamins, and minerals - as the rest of the population if they are to maintain good health and vigor. Older people, however, do have some special conditions and circumstances that affect how much of these nutrients are needed and in what form they are best utilized.

Some of the factors that can adversely influence the nutritional health of older people in developing countries are:

- **Lack of income to buy food of adequate quality and variety.** Pensions and social security systems to provide for those too old to work are the exception. Most rely on their families to meet their food needs. If that family is poor, food is likely to be preferentially allocated to income earners.

- **Diseases or chronic conditions that affect the eating process.** These can be gastrointestinal disorders that restrict the foods that can be eaten; conditions like arthritis or Parkinson's disease that limit our physical ability to buy and prepare foods; or confusion and memory loss that can cause missed or poorly prepared meals.

- **Dental and mouth pain that make chewing many foods uncomfortable.** Dental and malocclusion problems are very common in most developing countries as professional dental care is nearly nonexistent and false teeth tend to be poorly fitted makeshift affairs.

Leaf concentrate is an inexpensive product that can greatly improve the nutritional status of the high risk elderly population. Leaf concentrate is a very nutritious curd made by heating the juice of certain varieties of green leaf crops. It can be an inexpensive source of high quality protein, iron, calcium, vitamin A and other nutrients in the humid tropics where malnutrition is most prevalent. The soft texture of leaf concentrate makes it a very easy food for people with bad teeth or poorly fitted dentures to eat. Because it can be readily integrated into foods like tamales, dried pasta, and lemonade, that are convenient
and easy for older people to prepare and eat, it is especially well suited for prevention of malnutrition among the elderly.

By our mid-twenties the physical performance of our bodies has peaked. Gradually the efficiency with which we chew and digest food declines and we need to eat more of the same foods to absorb the same amount of essential nutrients. Protein, iron, calcium, and zinc are more poorly absorbed with advancing age. Many nutritionists recommend that older people get 12-14% of their calories from protein, as opposed to the 9% suggested for the general population. Often a reduced ability to absorb one or two essential amino acids can lower the quality of the protein in the food older people eat. In areas where the diet is based on staples like corn, sorghum, or legumes that have a marginal quality of protein this can be significant. Where the total quantity of protein is low or marginal, for example in regions where cassava, yams, or bananas are important staples, impaired absorption of amino acids can lead to protein deficiency.

The body's requirement for iron does not increase with age, (in fact post-menopausal women need less than younger women). However, the reduced efficiency of absorption can cause anemia in older persons with borderline consumption of iron rich foods. The little meat that they can afford is usually very tough and stringy, coming from animals who have not received a rich diet themselves. This is another obstacle to adequate nutrition for the elderly as they very often have great difficulty chewing tough meat due to dental or mouth problems. Dark green leafy vegetables, another source of iron, are quite fibrous and can also be very hard to chew thoroughly for people with poorly fitting dentures or missing teeth.

Calcium is another essential nutrient that is more poorly absorbed with advancing age. Dairy products are an excellent source of calcium, but they, like meat, are usually too expensive for low income elderly in the tropics. Perhaps even more limiting than price is the fact that the majority of elderly people in the world cannot digest lactose, or milk sugar, very well. Most adults can consume a small amount of milk (less than ½ liter per day) without difficulty, but larger quantities can cause uncomfortable gas formation, bloating and diarrhea. The main exceptions to this being people of northern European ancestry and some African tribes with long histories of cattle herding. Cheese and yoghurt don't usually cause this reaction because the fermentation process breaks down the lactose. For more information on lactose intolerance please see the chapter on Discussion Topics.

Dark green leafy vegetables are potentially an inexpensive source of calcium for these people. Greens have several limitations as food for elderly people in developing countries. As mentioned earlier, they are difficult to chew because of the high content of tough fiber. Many greens contain oxalic acid which can block the body's absorption of calcium.

Older people generally need fewer calories from their diet than their younger counterparts. Usually the amount of time spent in demanding physical activity is much less. Even in times of rest the body of a 70 year old typically uses about 10% less energy than when he...
was 20 years old. It is quite possible for elderly people to simultaneously suffer from being overweight and undernourished. For example, in parts of Mexico fats, mainly lard, and sugars which supply only calories, make up a large and growing part of the diet. With their decreased need for energy and reduced absorption of many other nutrients, older people can easily put on excess weight without assuring their other nutrient requirements are met. Because leaf concentrate is extremely rich source of a wide variety of nutrients and has an average calorie content, it is an excellent nutritional insurance for older people.

As a person grows older their immune system, like their digestive system, becomes less efficient. Older people are more prone to infections than younger adults. Infections are closely linked with nutrition. Malnutrition increases our susceptibility to infection and infection increases our nutritional requirements. Vitamin A is especially important in preventing infections as it helps to maintain the effectiveness of mucous membranes in the respiratory and digestive system, which is the body's first line of defense against invading micro-organisms. Leaf concentrate is the richest known source of beta-carotene which is converted to vitamin A within the human body. There is some danger of toxicity from overuse of high potency vitamin A capsules that are often distributed by clinics and development groups. Beta-carotene, on the other hand, is a non-toxic way to insure adequate vitamin A in the diet.

In summary, leaf concentrate is an inexpensive food that is extremely rich in of several of the nutrients most likely to be lacking in the diets of elderly people in developing nations. Leaf concentrate is easy to combine with inexpensive staples, and a wide variety of these combinations have proven acceptable in various cultures. Most of these foods are very easy to chew and digest compared to local alternatives.

Some resources for nutrition and the elderly:

**Nutritional Care of the Older Adult**  Annette B. Natow and Jo-Ann Heslin  MacMillan press NY 1986  306 pp

**Nutrition Screeening Manual For Professionals Caring For OLder Americans**  Nutrition Screening Initiative  Washington, DC  1991


**Nutrition Assessment: A comprehensive guide for Planning Intervention**  M. D. Simco, C. Cowell, and JA Gilbride  $35  Aspen System Corp.  1600 Research Blvd.  Rockville, MD 20850

CULTURAL ASPECTS OF LEAF CONCENTRATE PROGRAMS

Leaf concentrate doesn't do any good if people don't eat it. Whether children will eat leaf concentrate or not depends on many cultural factors. How the leaf concentrate is presented and how it is distributed play an essential role in any leaf concentrate program. This manual contains a few recipes that should give community workers some ideas as to how to incorporate leaf concentrate into traditional dishes. Peoples' tastes vary from region to region and the recipes will always have to be adjusted for this.

A public dinner to introduce leaf concentrate to a community can be very helpful if several dishes are attractively presented. If the women in your community are reluctant to get involved with the project you might try a cooking contest to see who can make the best recipe containing leaf concentrate. If a local judge or panel of judges can be recruited from well known local people and the contest connected with a community celebration of some type it may help gain interest and acceptance for leaf concentrate.

The method of distributing leaf concentrate to malnourished children in your community should be given a lot of consideration. Often the most seriously malnourished children live far from the community center. Their parents may be very busy, or discouraged, or sickly, or ashamed of their appearance. Any of these can lead parents to avoid bringing their children to breakfast or other feeding programs. Sometimes the fathers of malnourished children feel that if their children are in a nutrition program, it is an admission of their inability to provide for their families. Maintaining pride is of great importance. Generally speaking, the more the program appears to be a charity for the poor, the more social stigma is attached to it.

The ideal approach is often to provide nutritional education to the parents while at the same time appealing directly to the children. Sometimes a few balloons or small toys can generate a lot of interest. If attendance is not consistent at a feeding center, a weekly prize of some kind could be given away in a lottery open only to children who have attended every day that week. If a video cassette player is available, perhaps one day a week a children's movie could be shown while atol or churritos or some other leaf concentrate snack are fed. If it is made fun for the kids the parents will be more enthusiastic and half your work will be done.

Families with malnourished children often have a lot of problems. Sometimes alcohol or drugs, or learning disabilities, or emotional problems prevent people from taking good care of their children. Sometimes the problem is just economics; the lack of adequate
income. Whatever the case, it is very important that they be treated with respect. It is also important that nutrition workers don't give up on families with malnourished children, even if they are ungrateful and uncooperative. They may be cynical about these types of programs, perhaps with good reason, and it may take several home visits to convince them that you are for real.

The broader the base of support you have in a community the greater the chance of the leaf concentrate project taking root. It is always a good idea to try to get the doctors and other health workers in the area interested in the project. If you can enlist social service workers in the area or university students doing their social service work, they often have a lot of enthusiasm. Most often, however, a group of local mothers is by far the most important support group for these programs.

There are no fixed rules for introducing new foods. The best you can do is to pay attention to what the local people say and feel, and to learn from your own mistakes and those of other groups doing similar work.

**THE COMMERCIAL MARKET**

While most of this manual has focused on the use of leaf concentrate to improve the nutritional status of young children, we are also aware of a great deal of interest in small scale marketing of leaf concentrate products. Leaf For Life is working with small women's co-operatives in several countries that are trying to generate income through the sales of leaf concentrate products. Most of these co-ops have a dual motivation of trying to improve the diet of local malnourished children, while, at the same time, earning a basic salary or wage for their labor.

The requirements for successfully marketing leaf concentrate products are very different from those of a successful nutrition intervention program. The biggest difference is in the targeted consumer. In nutrition programs we are mainly trying to reach young children whose parents are poor and often quite uneducated. In marketing leaf concentrate we frequently find ourselves targeting well nourished, well educated, middle class urban people who have recently become concerned about health and nutrition.

This "health food" market tends to be small and very fussy, but willing to pay high prices for foods they feel will improve their health. There is often a huge mark up on the prices of foods sold through 'health food' shops because the volume of sales is small. This means that even though the price to the consumer is very high, the price to the producer may not be. Sometimes these shops are unwilling to carry products containing salt, refined sugar, or artificial flavors. At the other end of the market, efforts to market leaf concentrate foods in low income communities, revolve around a low enough price and acceptance of a new food.

It may be helpful to relate some of the experience of the La Casa de la Salud women's co-operative in northern Mexico as they tried to market leaf concentrate products in nearby villages and in the city of Mexicali. After 2 years of producing a small quantity of leaf
concentrate foods for their families and neighbors in their village of about 2000 people, they decided the only way their project could continue was through the sale of products.

Many of the leaf concentrate foods that had been eaten in their village, like puddings, frozen confections, donuts, and meat substitutes were considered as possible products for local markets on a small scale. However, their short shelf lives made them inappropriate for larger scale marketing in Mexicali. After a period of test marketing several products, the co-op decided to focus their sales efforts on three; dried pasta, syrups for making lemonade and other drinks, and fried corn snacks, called churritos.

Each had advantages and drawbacks. The pasta was attractive, convenient and stored extremely well, but per hour production output was very low because a hand operated machine was used to make it. The drink mixes required much less labor, as they could be made in a kitchen blender by combining leaf concentrate, lemon juice and sugar. The bottles and labels needed to package this sticky liquid on a small scale, however, were quite expensive. Churritos were very popular with children and teenagers and were well suited for giving out as samples, as they are ready to eat. Because people seem quite willing to accept novelty in snack food, it was far easier to get people to try churritos than pasta, which had to be planned into a conservative meal pattern. The churritos had a shorter shelf life than either the pasta or drink mixes and there were some quality control problems. Fluctuations in moisture content, oil temperature, and frying time made it difficult to get a uniform product. Some churritos were too hard, others too greasy.

Having chosen three products to sell, the next steps were to promote them in Mexicali, and to find ways to make them more efficiently, thus lowering per unit costs. The co-op had attractive labels printed for all three products. A pegboard product display was designed and given free to storekeepers willing to try selling these new products. Stacks of free flyers explaining the value of leaf concentrate were left for customers at each store. Articles about the co-op and their products were submitted to local newspapers and a representative went on a local radio show to raise public awareness.

On the production side, steps were taken to increase output, lower costs, and improve quality. A larger commercial blender helped with drink mix production and an improved rack sped up the drying of the pasta. A nylon dieplate replaced the steel one in the churritos maker, which made for smoother churritos that absorbed less of the expensive oil. Bulk purchasing of corn meal, cooking oil, sugar and other supplies lowered costs. The factor most limiting to production, however, was the low output of leaf concentrate itself.

`La Casa de la Salud' has not been able to become a profitable co-op selling leaf concentrate products yet. Problems of irregular supply of leaf crop, low hourly output of leaf concentrate, and difficulties in transporting the products to market are large obstacles that haven't yet been overcome. The co-op has not been able to get stores in the low income barrios of Mexicali or neighboring villages to carry the products regularly. Volume of production is so small that only the very high retail prices charged at the middle
class health food stores, hold promise of providing a steady income to the women. And of course, these are the people who least need nutritional support.

Before dismissing the co-op as a failure, however, it is important to remember that they were never purely a business venture. In addition to running a profitable co-op the women wanted to take effective action against the malnutrition that is prevalent in their area. Approximately 25% of their production was donated to poor families in their village and to primary school children in a very run down barrio of Mexicali. The co-op also helped to meet several social needs of the women and their families. Much of the appeal of the co-op to its members is that it offers part time work in the village, so that family life is not severely disturbed by the women seeking additional income. The women arrange their own work schedules and their young children can play in the adjacent churchyard during their 3-4 hour shifts. The co-op has a fund set aside to help members with emergency expenses. Most of the other employment opportunities for women have long inflexible hours and transportation problems.

Despite these social benefits to the women and the community, the co-op is in serious trouble. Our experience with marketing elsewhere has been similar. It is extremely difficult for a small democratic co-operative making a new product to compete with large mechanized, well financed food companies. From the hard cold viewpoint of business the social benefits to the community are often just an unacceptable overhead. Regardless of the difficulties involved, successful marketing of leaf concentrate is essential if this food is to play a significant role in feeding future generations. Below are a few points that any group thinking about marketing leaf concentrate products might consider before getting started. These aren't intended to discourage people, only to offer some realistic perspective on the food business.

- **The importance of selling products and difficulty of doing it are always underestimated.** In most businesses sales workers are paid far more than production workers, yet co-ops often view sales as a very secondary part of their operation. Women in leaf concentrate co-operatives often see the work as an extension of the cooking and feeding they traditionally do at home, and as such they are quite familiar with it. The aggressiveness required of sales workers is often uncomfortable for village women. Good sales people have real skills and talents that shouldn't be taken for granted. They understand people. They are creative, enthusiastic and persistent in the face of repeated rejections. They are a tremendous asset to any group trying to market leaf concentrate products.

- **You will need to put some money into getting things rolling before you begin making a profit.** Small co-ops often balk at spending their precious money on things like advertising and promotion. Business people understand that, especially when introducing new products, substantial effort has to be put into giving the product away before it can be sold profitably. You will need to plan on expenses like free samples, product displays, contest prizes, and radio advertising to launch your business.
- **Quality control is essential.** If you are selling pasta, don't try to sell the bags with lots of broken pieces. Make sure your products look beautiful, not just OK. Someone who buys one bag of churritos that are hard or have a burnt flavor is unlikely to ever buy them again. You are responsible for making sure your products are not being sold in stores when they are too old. Be sure that your bags are not sealed in such a way that people might end up with a staple in their mouth. If your bags say they contain 100 grams, make sure they do.

- **Be conservative in your financial calculations.** 10 kgs of ingredients will never make 100 bags of products with 100 grams in each. Some of your products will always be lost through spillage. Some prepared foods will usually be broken or burned during processing. If your foods are tasty and ready-to-eat a surprising amount may be eaten by workers before heading to market.

- **Some unexpected expenses should be expected.** All of your equipment as well as your building will need periodic maintenance and eventual replacement. It is better to slightly overestimate your costs and be pleasantly surprised, than to fail to meet unrealistic expectations. Dig in for the long haul. Most successful food businesses lose money for at least their first year before becoming profitable.

- **Take advantage of available resources.** Many governments have set up agencies to help small co-ops and businesses get started. There are a growing number of non-governmental organizations that are promoting small worker owned businesses as a way out of poverty. Some of these, like the Grameen Bank in Bangladesh, offer small loans with low or no interest. Others can offer help with teaching workers unfamiliar skills like accounting, marketing, or equipment maintenance.

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**THE SOCIAL MARKET**

The line between business and charity is often blurry and getting more so every day. Increasingly development agencies are interested in supporting projects that will one day become self-supporting small businesses or micro-enterprises. The problem is that it is very difficult for a small women's group to become a profitable business by selling a new product (LC) to a group of people who are notoriously impoverished, namely malnourished children. The need to become financially self-sufficient can have some interesting effects on small groups. Groups that started with the honorable intention of
reducing childhood malnutrition in their community, often end up with the dubious objective of selling rich people LC at the highest possible price.

We have moved into an arena sometimes called the social market in an effort to resolve this contradiction. Broadly speaking, social marketing is selling products or services through organizations or institutions that are trying to perform socially beneficial services. These include orphanages, clinics, old age homes, schools, homeless shelters, feeding programs for malnourished children, refugee support programs, and a range of other programs set up to help out societies more vulnerable members. For the most part these are programs that need to provide the essential nutrients to groups of people under their care. Because they need to regularly buy nutritious food in large quantities they could be an ideal market for leaf concentrate in many ways.

Selling LC to them is quite different than selling it in the commercial market. Typically, these institutions have very tight budgets and need to buy food at low prices. However, they are often sympathetic to some of your group's objectives. They may want to help support your women's co-op by buying LC because they agree that the income generating possibilities for village women is linked to the problem of poverty that they are working on. They may like the idea of using local resources and paying local workers for the production instead of bringing in imported foods. On the other hand, you may be competing directly with food that is given away for free by the World Food Program, the government, or the church.

Besides being able to reach people who really need the LC, the biggest advantage of social marketing is that some of these institutions serve a lot of people and need a lot of food. They can buy large quantities of LC. For example, we are negotiating with a group called Alianza Urbana (Urban Alliance) in Mexico. They run 82 barrio feeding centers. Soynica in Nicaragua is running 26 centers with an average of 85 children and mothers in each. This is 2200 people or far more than you are likely to reach by selling to a handful of small retail shops. A once a week snack for thousands of school children could absorb all the production from a small LC production coop. We are just beginning to learn how to do effective social marketing, and have a long way to go. Below are a few points that have been helpful so far:

1. **Calculate the lowest price that its is worth selling your LC for.** If your price is too high you won't interest the social institutions, if it is too low you won't recover your operating costs. It is hard to raise prices once they are set.

2. **Sell dried concentrate or simple LC foods that have a long shelf life.** Most institutions have their own kitchen staffs and will not want to pay you the additional labor costs of preparing more complex foods like churritos. Dried LC enables you to deliver a sack every three weeks instead of delivering perishable fresh LC every two or three days. This reduces the cost of transportation.
3. **Make a list of all the social institutions in your area.** Include address, telephone number, and contact person. Arrange these in the order of those you think most likely to purchase LC first and least likely last. Begin at the top of the list visiting the institutions, meeting the directors and dropping off information about LC and your project. Leave some samples of both dried LC and of at least one appealing local food that can be made from dried LC.

4. **Arrange a return visit with free samples of an LC food.** If the institution is not too large, bring enough for everyone to try it. Directors are far more likely to allow you to bring something for a midmorning snack than for a meal, because the meals often have menus that have to be approved by someone beforehand. This should be short, fun and informative. Green frog cookies for children or green Christmas tree cookies at Christmas time are good for getting people interested. Take photos if possible.

5. **Offer to send someone from your project to help the kitchen staff learn to cook with LC.**

6. **Ask the director to consider buying a small but definite amount each month.** If they would like to buy LC and feel that it would be a benefit to their institution but can't afford, ask them to write you a short letter expressing their interest. You can then approach social clubs, churches, etc. with this letter asking them to help the institution purchase a local high nutrition food.

7. **Ask for testimonials from institutions that have used LC for a while.**

**MARKETING FIBER**

Make every effort to find a market for the leaf fiber you produce. If you cannot sell it to dairy farmers for cash, perhaps you can arrange a trade of your fiber to someone raising animals for some service or product that would help your business. Again, with an unfamiliar product you may have to give it away for a while to convince people that it is worth buying. If you can interest an innovative and successful farmer in using the fiber, his endorsement may make it easier to sell to others. Similarly, if you can get a local university of agricultural school to test the feed value of the fiber (with donated fiber), it may be easier to get the attention of farmers.

If you have the space it may be worthwhile drying or ensiling the fiber so that it can be stored and sold at a time when livestock feeds are at their lowest levels and highest prices. Another alternative is for the project or cooperative to raise its own animals for sale feeding them with the fiber. This substitutes a known commodity (the animals) for one of unknown value (the fiber). This can be a sound financial strategy if the people involved in the project are familiar with raising the animals and feed for the animals is expensive enough to justify seeking lower cost alternatives. It can get complicated having joint ownership and responsibility for animals.
The purpose of this chapter is to familiarize LC workers with some of the controversial topics that sometimes come up when one is working on LC programs. For the most part there are no definitive answers to the questions posed here. The aim is simply to present a quick background and some useful perspective on questions that many volunteer field workers and staff people have encountered. It is beyond the scope of this manual to explore these issues in the depth many of them deserve. These are arranged in three groups; production issues; nutrition issues; and the bigger picture.

Production

"Should we be practicing organic farming methods?"

"Organic farming" generally refers to raising crops and animals without the use of synthetic fertilizers or pesticides and herbicides. There are many closely related concepts like regenerative farming, bio-dynamic farming, natural farming and sustainable agriculture. Underlying them all is the idea that farmers must take good care of the soil and that a healthy soil will produce healthier plants which will be more able to take care of themselves. Much of the initiative comes from consumers who feel that modern agricultural techniques produce food that is tainted with pesticides. Increasingly, the organic agricultural movement is driven by concerns about the environmental contamination and high energy costs of modern farming. There is almost always present a philosophical element as well. This boils down to the idea that humans need to remain close to the natural cycles of life and that industrialized agriculture turns the living biological relationship of food production into a mechanical one.

Many people become interested in leaf concentrate through their involvement with organic gardening, health foods, vegetarianism, or other aspects of what might be called a search for a more natural way of life. Sometimes these people become disillusioned with leaf concentrate projects when they find out that we may use leaf crops grown with chemical fertilizers or pesticides.

Everyone has their own lifestyle and their own views, but it is helpful to try to keep some perspective when working with leaf concentrate programs in developing countries. The idea of "organic gardening" evolved in wealthy nations as a response to perceived problems in industrialized food production, after they were producing large food surpluses. Most of the developing countries only have industrialized agriculture for export crops, and suffer from inadequate production levels of basic foods. Much of the wisdom of the "organic agriculture" movement is tied to conditions in the temperate climatic zones where it evolved. In hot tropical climates many of the organic strategies don't work nearly
as well. For example, composting which is central to organic agriculture is vastly less useful in the tropics because nitrogen is lost to the air so much more quickly.

Organic farmers advocate using the slow acting rock phosphate, rather than the synthetic super-phosphate for soils deficient in that nutrient. However, tropical soils are far more likely to be deficient in phosphorus and transportation is typically so much more expensive, relative to income, that the hauling of low value rock phosphates makes less sense than it does in the US. The question of pest control is also quite different in the tropics where there is no long cold winter to depress insect population and freeze out soil nematodes. "Organic farming" approaches tend to be long term solution like building up the humus level in the soil or gradually bringing pest and predator populations into equilibrium. The logic of these strategies is essentially unchallenged. The difficulties of implementing them in terms of leaf concentrate projects are several.

Very often we are operating under the terms of a two year grant, and need to show measurable results within that time. Sometimes the land being used is on a short term lease or the tenure is very insecure. This makes it difficult to encourage people to make the long term investments in soil building. Our primary objective is generally to improve the nutritional status of the people, especially children, in the area of the project. Agricultural innovations are necessarily secondary to this objective. When there is a conflict, for instance a leaf crop will be lost to insects unless pesticides are applied immediately, we are obliged to take measures to protect the crop. This is not a hypothetical situation. It happens often in practice.

If we are not in a position to impose "organic" orthodoxy in our projects, neither can we completely ignore the essence of the "organic" message. For a range of economic, environmental and health reasons we need to use the most "organic" methods that are appropriate to a given situation. If agriculture is dependent on huge energy subsidies or is rapidly degrading the resource base that it operates from it is not sustainable. If it's not sustainable, its bad agriculture. Leaf for Life is part of a growing movement towards low input and low impact agriculture that is not based on doctrine, but rather on observation of specific conditions. We need to be aware of the full range of available responses to crop problems and choose those least likely to cause damage. For example, we have planted neem trees at one of our production sites in Nicaragua because the neem seeds can be made into a safe, effective low cost insecticide. Sustainable agriculture is a direction to move towards not a set of prescribed practices.

"Should we encourage the production of animals for meat in leaf concentrate projects?"

The wisdom of raising animals for meat is being questioned by more people than ever before. The doubts come from concern over the ethics of our relationship with animals, and perceived nutritional and environmental problems related to the production and consumption of meat. As with the arguments for "organic" agriculture, most of these viewpoints developed in industrialized temperate zone societies that didn't suffer from
food shortages. Many people have chosen to become vegetarians (eat no meat) or vegan (eat no meat, eggs, or dairy products) in response to these concerns.

The argument against meat is strongest when aimed at the US feedlot beef production. Huge quantities of edible food (mainly corn and soybeans) are fed to fatten cattle held in cruel confinement. The fatted cattle then provide heart disease and cancer for the overfed people who eat them. In the tropics very little humanly edible foods goes to animals. They are seen much more as a means of converting less valuable resources like the tough tropical grasses on poor rangeland and domestic garbage into a valuable food. Where protein-energy malnutrition is common and anemia is widespread, the highly digestible forms of protein and iron in meat, even in small quantities, can be important to the diet.

Ruminants like cows, goats and sheep can convert indigestible cellulose fiber to useful foods for humans. With few exceptions the most economical use of the fiber remaining from leaf concentrate production is to use it produce milk or meat from ruminants. There are other possible uses for this fiber, such as improving the soil, making bio-gas, or making paper, but none compare to animal feed in economic value to the producer. Beside the value of meat or milk, animals also serve as a source of power for agricultural work and transportation in many developing countries. When trucks and tractors wear out new ones must be bought, but horses and cattle can reproduce themselves. This point is very important to impoverished farmers. The manure from farm animals is also important for maintaining soil fertility. Some groups we work with may elect not to raise animals with the leaf concentrate fiber for various reasons. Whether to raise animals should be decided by the local group after they have been well informed about the alternative uses for the leaf concentrate fiber.

"Shouldn't the processing of leaves be continuous rather in batches?"

There are two basic approaches to leaf concentrate processing: Continuous Processing and batch processing. Continuous processing allows for the uninterrupted flow of materials from the time the leaves enter the workshop until the leaf concentrate is separated. It is the type of system normally used in most industrial processing, and can be very efficient in terms of output per hour of labor.

When the leaf concentrate is made by repeated steps with breaks in between, it is a batch process. So, for example, if you have 200 kg of leaves to pulp and you feed it through a hammermill it is a continuous process. But when you pulp it 3 kg at a time in a blender it is a batch process. A belt press allows for continuous processing, but a lever press or jack press handles a batch at a time.

One part of the process could be continuous and another part batch. For example, in Mexico we use an impact macerator which allows for continuous pulping, then a batch type hydraulic press table and a batch type cooker. The advantage of continuous processing is lost if any part of the process is done by batches, because the material flow will have to stop and wait for the batch processing.
With the obvious advantages of continuous processing, why do we ever use batch processes? Continuous processing often require more engineering to make sure all the parts of the system are matched for speed. If your hammermill processes 500 kg per hour but your belt press can only handle 200 kg per hour you won't have an efficient continuous process. When you are dealing with a relatively small volume of material, say under one ton of leaf per day, the initial costs of designing an efficient continuous process leaf concentrate system may not be justified. The highly variable conditions of work one frequently encounters in leaf concentrate production in developing countries can also make managing a coordinated system very difficult. Often the quantity and quality of the leaves will vary greatly from day to day as may the number of workers. Even the voltage of the electricity can vary considerably. If anything goes wrong with a continuous process the whole system comes to a halt, whereas with batch systems it is often possible to keep processing by making modifications only in that part of the process that is going wrong. Batch systems tend to be simpler, more flexible, and less expensive to set up than continuous systems. Conditions in developing countries are usually such that flexibility is an enormously valuable characteristic in a processing system. The great advantages in efficiency of continuous systems probably comes into play at a rate of about one ton per day or more.

"Shouldn't food processing equipment be made of stainless steel?"

In most developed or industrialized countries there are rigorous health codes that determine what materials may come in contact with food during processing. Stainless steel is the standard for most food processing equipment where these codes are in force. It is extremely resistant to rust and can be cleaned very thoroughly. The problems with using stainless steel equipment in nutrition programs in developing countries are threefold; it is expensive; it is hard to find; and it is hard to work with.

When stainless steel is not available or is too expensive for a project, what alternatives can be used? We frequently use plastic containers of various sizes. They are relatively inert and can be cleaned well unless they are badly scratched. Polyester and nylon cloth are often used to replace expensive stainless steel screen. They are quite inert and can be cleaned but will break down more quickly from abrasion or friction. Some synthetic cloths and plastics will photo-degrade or gradually break down from exposure to ultraviolet radiation sunlight. Some plastic are certified food grade even in wealthy countries.

Wood is a traditional material used in food processes. It is often employed for chopping boards, rams for pushing leaves into grinders, feed chutes, pressing and drying frame trays, etc. Increasingly we have been using non-toxic wood sealer, such as salad bowl sealer to protect wooden equipment used in our processing. This should reduce bacteriological contamination.
Sometimes galvanized sheet metal is used in trays and washtubs. This is steel plated with zinc. It should not be used where the zinc will be quickly worn off or where strongly acidic substances stay in contact with it for more than a few seconds.

Mild or rolled steel is used when great strength is needed, for example in the frame of the press tables or the legs of the macerator. Mild steel rusts quickly when it is exposed to water or even damp air. For the most part rust is not a dangerous contaminant. In fact, it can contribute useful amounts of iron to the diets of anemic people. When a steel surface becomes rusty, however, it is much more difficult to clean and the pocked surface creates hiding places for bacteria. Rusty steel also is visually unappealing and this is quite an important consideration when you are trying to convince someone of the value and safety of an unfamiliar product like LC. Aluminum is used in cook pots for heating the leaf juice and sometimes in other processes. Its limitations are described below.

Some rules of thumb for making sure your processing equipment is safe and appropriate.
- Check with local health codes and visit similar food processing shops in the area.
- If stainless steel is available and you can afford it, use it in preference to other materials.
- Make certain that your equipment is designed so that there are not impossible to clean places where harmful microorganism can breed on food particles.
- Use material that won't easily chip or wear off.
- Make sure the leaf juice is brought to a full boil to kill any bacteria that may have gotten on the leaves or equipment.

"Is cooking in aluminum pots bad for you?"

Some people have expressed concern about contamination from aluminum cookware. Some evidence shows a possible link between high levels of aluminum in the diet and Alzheimer's Disease. Cooking or leaving very acidic liquids such as tomato sauce in an aluminum pot for an extended time could cause some metal to be dissolved. This should be avoided. If the inside of the pot is very rough textured, or if it is scratched up from scraping with a metal spoon or from cleaning with a metal scouring pad aluminum is more likely to leach into food because of the increased surface area of the metal. The juice from most leaves that would be used in this process are slightly acidic (pH 5.6 - 6.4). This is not acidic enough to cause A smooth finished heavy gauge aluminum pot should not contaminate juice at this acidity heated briefly to the boiling point. It is a good idea to avoid vigorous scraping of the bottom and to replace these pots when they become very scratched.

There have been cases of zinc contamination from very acidic foods being cooked for long periods in galvanized cookware. Antimony poisoning has occurred where acid foods have been cooked in chipped enamel cookware. Both galvanized and enamel pots should be avoided for heating leaf juice repeatedly in leaf concentrate programs.
Nutrition

"If people get enough calories in their diet, won't the protein take care of itself?"

In the 1950's and 1960's there was a general focus on the lack of protein in diets of people in tropical countries. Numerous schemes were developed to introduce protein enriched foods and drinks into populations where malnutrition was prevalent. Weaning foods like INCAPARINA were introduced with carefully formulated amino acid balance to increase protein intake in low income families. There was generally a lot of research on alternative protein sources done by governments, universities, and food companies like General Foods, General Mills, and Coca Cola. Fishmeal from dried Peruvian anchovies was advocated as a solution to the world's protein deficiency, as were single celled proteins grown on petroleum refinery byproducts. Chlorella algae grown in illuminated clear plastic tubing was promoted as a substitute for producing protein food on land. Leaf concentrate, which was then called leaf protein, was very much a part of this worldwide search for a means to close the perceived "Protein Gap".

Around 1972 several studies came out suggesting that protein requirements had been overestimated and that a shortage of energy or calories in the diet was a far more common problem. It was argued that as long as one was receiving an adequate amount of calories, that protein would take care of itself. That is, a person eating a tradition grain based diet would take in enough protein as long as he got enough calories. As this point of view became the consensus opinion of nutritionists and development agencies, interest in novel sources of protein, like leaf protein quickly diminished. It was replaced by a passion for calories and to produce more grain. All people needed was "more of their traditional diet".

This change in outlook roughly coincided with what has become known as "The Green Revolution". This was a worldwide revolution in the production of grain led by the development of high yielding short stemmed wheat and rice varieties in Mexico and the Philippines, respectively. The new hybrid grains did indeed produce huge crops, and created some optimism that hunger would be soon defeated by plant breeding science. The "Green Revolution" crops required far more in the way of fertilizer, pesticide, machinery, and irrigation than the older grain varieties. By the 1980's grain yields were reaching a plateau. Any further increase in yields were coming only from proportionately greater inputs of fertilizer and energy.

A major unintended consequence of the introduction of the high yielding varieties was a dramatic decline in the consumption of peas and beans in many countries. The large farmers who could afford the inputs diverted land that had been growing peas and beans
to produce the more profitable new grain varieties. This reduced the supply and increased
the price of these foods, which have traditionally been a vital source of protein in many
cultures. In India, for example, per person consumption of peas and beans declined by half

In 1993 few people believe the "Green Revolution" can answer the world's hunger
problems in the long term. The leading role of calories and the need to simply "eat more of
the traditional diet" continue to dominate nutritional development thinking. However,
nutritionists are beginning to see the traditional diets changing rapidly in many areas,
powered largely by rapid urbanization in the tropics. Highly processed and heavily
promoted convenience foods are being eaten in quantities that must be considered in
terms of nutritional impact on millions of people. The importance of vitamins and
minerals, collectively called micronutrients, is also increasingly being stressed. No one
claims these requirements will automatically be met if calorie needs are met.

It is very unlikely that we will return to the days of "the Protein Gap", but it is important
to maintain some perspective as waves of revolutionary nutritional studies are reported in
the popular press. It is a time of great interest in nutrition and impressive strides are being
made in our understanding of this science. Read reports about new nutritional information
carefully. Often these are "preliminary findings" based on tiny samples of people. Amid the
flurry of reports, consensus of informed opinion will gradually form.

"Wouldn't people be better off just eating more dark green leafy vegetables than making leaf concentrate?"

The health giving value of greens, such as kale, spinach, turnip and mustard greens, in the
diet is almost universally known, yet hardly ever are they eaten in adequate quantities by
children at risk of malnutrition. Very rarely can projects geared towards promoting
gardening show an improvement in the health of the children in the area.

Greens contain a lot of fiber. Adding fiber to the diet is important for many adults who eat
highly refined diets. Children in developing countries, however, usually get plenty of fiber
from the grains and beans and fruit in their diet. The high fiber content of greens can
aggravate diarrhea and reduce absorption of iron in these children who frequently suffer
from both diarrhea and anemia.

Although they are productive and easy to grow, greens tend to be very perishable and
difficult to market because they are usually 85-90% moisture. In the heat of the tropics,
where most families don't have refrigerators, greens last only a day or two before
becoming inedible. Because so much of the weight of greens is water and indigestible
fiber, they are often quite expensive as a source of nutrients.

Children frequently don't like the strong flavor of many greens and won't willingly eat
them in many cultures. The strong flavors are often attributable to antinutrients like
nitrates, oxalic acid, tannins, and saponins. These antinutrients should not be consumed in
large quantities by anyone, especially malnourished children. The leaf concentrate processing removes most of these antinutrients, nearly all the fiber, and the bulk of the water in greens, making it generally more acceptable and more nutritious than the greens it is made from.

"Wouldn't it be cheaper and easier to fortify common foods with nutrients that are in short supply?"

Often there is disagreement among nutritional workers on how to best correct a nutrient deficiency in a given population. The approaches will range from giving capsules or tablets of the nutrient to encouraging people to produce and eat more traditional foods that are rich in the missing nutrient. Some success has been achieved by fortifying a common food with the missing nutrient, such as the fortification of salt with iodine. Focusing on vitamin A deficiency, a consideration of capsules and fortification is given below and they are compared with leaf concentrate as a vehicle for countering the deficiency.

**High Potency Vitamin A Capsules:** These are very effective at rapidly reversing deficiency symptoms. They are relatively inexpensive and very compact for easy transport into remote areas. The capsules also tend to have the affect of turning a food and nutrition problem into a medical intervention one. Many development workers are dismayed by passive attitudes about maintaining good health. Some feel the proliferation of pills and capsules discourage people from making changes in diet and lifestyle, that would give them better control over their health. The widespread use of capsules may also increase a feeling of dependency on outside technologies among the health workers in developing countries. It is difficult to administer a program of high potency vitamin A capsules without some trained health workers in the area, as excessive doses are toxic.

**Fortification of Common Foods with Vitamin A:** This seems to be working quite well in a few locations. Sugar has been fortified with vitamin A in parts of Guatemala with some success. Salt, flour, milk and a few other foods have been suggested as vehicles for vitamin A fortification. This may be promising where large numbers of people eat predictable amounts of certain foods that can be processed under controlled conditions in a central plant. Where fortification doesn't usually work well is in rural areas where most of the foods are locally grown and prepared. These are, not coincidentally, areas where malnutrition is prevalent.

**Local Production of Leaf Concentrate:** Leaf concentrate is something of a midpoint between the simple growing and eating more greens and the more complex, more centralized approaches of capsules or fortification. It seems well suited to small co-ops, school programs, or small business. It takes some effort and capital initiating LC programs, but it is a food that has other values (like iron and protein) in the diet of malnourished children. Some of the leaf concentrate foods like lemonade syrup and dried...
pasta store well and are very convenient. They are basically ways of preparing dark green leafy vegetables that children will accept well.

"Why do you use sugar in LC drink mixes? Isn't sugar bad for you?"

On several occasions people have objected to our use of LC drinks sweetened with white sugar in child nutrition programs. To convey some idea of how complicated these issues are and how we go about sorting them out, I've outlined the arguments that came up for and against using sugar in these programs.

Arguments against use of sugar fall into three basic categories: 1. tooth decay 2. empty calories 3. other. Tooth decay is dramatically less with drinks than candy etc., as it is dilute and doesn't stay in the mouth long or cling to tooth enamel. The empty calorie argument is greatly offset when used with LC, which is low in calories and high in most nutrients. Other arguments include several related to blood sugar equilibrium problems, including Feingold and other's theory of sugar intake as a cause of hyperactivity in children. This has been largely refuted by a number of well controlled double blind experiments that showed no correlation between sugar and hyperactivity in children. Children are much more able to digest and absorb large amounts of sugar than adults. Strong reactions to high sugar intake such as hypoglycemia are very rare, and probably the large majority of such reactions are psychosomatic in nature.

Some preliminary studies warn of problems from glucosinated proteins (glucose molecules attaching themselves in a rather unpredictable way to certain protein molecules) with possible negative impact on eyes and kidneys and nervous system. Diabetes may be linked to this response. This is still very sketchy stuff and probably linked to long term high sugar diets. There are some indications of slight addictivity from high intakes of refined sugars. Some biochemists and nutritionists feel that high refined sugar intake could aggravate diarrhea because it is such a readily available energy source for bacterial growth. Complex carbohydrates break down more gradually and may be less likely to stimulate bacterial outbreaks.

Honey and brown sugar would behave so similarly in the body that its unlikely to be worth much trouble or money to switch. The LC is rich in the trace minerals that they would supply in small quantities. A number of other benefits have been claimed for honey, over the years, but usually price eliminates it from consideration for use in nutrition intervention programs.
Arguments for using sugar also fall into 3 categories: 1. cheap source of calories. 2. improves palatability and acceptance. 3. helps preserve foods. Many nutritionists would argue that in a marginally nourished population like low income Nicaraguan children, increasing caloric intake is the first priority and that sweet drinks are a reasonable and inexpensive way to do this in sugar producing regions. Drinks typically have less substitution effect than solid foods. That is, two glasses of a sweet drink may add more calories to a child's diet than an equivalent number of calories from a solid source because the mothers more often reduce other food given the child if he receives a solid supplement. The benefit of making a marginally attractive food like LC acceptable to children shouldn't be overlooked. If they will drink two glasses with some extra sugar and one without it, the benefit of the addition LC and lemon juice will almost certainly outweigh the negatives of the added sugar. Increasingly, sub-optimal hydration is seen as a health problem in many 3rd world populations, where high temperature and low availability of good water are found. This can cause kidney problems, electrolyte imbalances, constipation, and other difficulties. This is another benefit of the drink. It is not clear at what point the sugar content would offset the value of just the additional water.

The high osmotic pressure of sugar sucks moisture through bacterial cell walls and makes a cheap preservative that is also a source of calories. Usually liquids greater than 67% sugar are relatively stable. 1.8 kg sugar mixed well with 1 kg 60% LC should be quite stable. A rule of thumb is to emphasize complex carbohydrates as energy sources and try to keep the percentage total calories in the diet from refined sugars to around 5%. This can be extremely difficult in tropical sugar exporting countries.

"What are antioxidants and why are they so important?"

In what is becoming one of the biggest nutrition stories of the century, scientists are finding that many diseases may be closely tied to the cumulative cellular damage done by free radicals. Equally important, they are finding that several compounds called antioxidants exist in common foods that can block these destructive oxygen reactions. Free radicals are unstable molecules that can be created by normal metabolic processes, or from environmental factors like cigarette smoke, ultraviolet radiation in sunlight, and a range of chemicals that people are routinely exposed to. An increasing number of researchers feel that dietary antioxidants are the realistic way to interrupt this cellular deterioration that appears to be linked to many types of cancer, heart disease, Parkinson's disease, cataracts, and dozens of other health problems. Much of this research is still in preliminary stages but, the evidence is rapidly piling up that increased dietary intake of antioxidants is a sound strategy for better long term health.

There are many different compounds. Three of the most important antioxidants in the human diet are beta carotene, vitamin C and vitamin E. Leaf concentrate is the richest known source of beta-carotene and a very good source of vitamin E. It
contains almost no vitamin C. Some of the other known antioxidants and important food sources of them are given below:

- **Quercetin** - yellow and red onions, red grapes, broccoli, and yellow squash
- **Ellagic acid** - strawberries, blackberries, blueberries, cranberries, grapes, apples, Brazil nuts and cashews
- **Glutathion** - broccoli, parsley, and spinach
- **Lycopene** - strawberries and tomatoes
- **Oleic acid** - olive oil
- **Selenium** - brazil nuts, seafood, sunflower seeds, and beef liver
- **Phytates** - grains and legumes

"Should milk be used in feeding programs?"

In several famine situations where donated milk made up a major part of the diet, many people suffered from serious intestinal gas and diarrhea. This was due to a widespread genetic inability to digest the sugar lactose, which is found in milk. The undigested milk sugar ferments in the intestine causing gas formation, bloating and sometimes diarrhea. Because of these problems one sometimes encounters a very negative attitude about the use of milk in feeding programs. There has been some dumping of powdered milk into developing countries to maintain high milk prices for farmers in both the US and Europe. Before 1972 there was tremendous nutritional emphasis on protein and the main milk protein, casein, is considered a benchmark against which to judge protein quality. It was a common belief that milk was an ideal food, partly due to the American Dairy Association's extremely successful lobbying efforts.

Until about 1965 USAID (United States Agency for International Development) was unaware of the extent of genetic lactose intolerance in various populations and there have been accusations of cultural chauvinism because of this. Only among people of northern European ancestry and a few African tribes with long histories of cattle herding, do the majority of the adults tolerate milk sugar well. The percentage of the adults who are intolerant varies greatly from culture to culture, with almost 100% of some groups, like the Thai, intolerant. Other groups, like US blacks, only about 65% are intolerant.

Children up to six years of age are generally able to digest lactose. Even lactose intolerant adults can usually utilize small amounts of milk (up to about ½ liter per day) without discomfort. Lactose intolerant people produce some lactase, the enzyme responsible for breaking down milk sugar, but this tends to decline rapidly with age. If you are working with programs involving adults you should find out what the levels of lactose intolerance are before introducing large quantities of milk. Allergy to milk is usually related to the protein and is much more rare than lactose intolerance, though the two are often confused in Latin America and other places.
Bigger Picture

"Isn't the normal diet people eat closely tied to their culture? Will they accept new foods like LC?"

It is very difficult to introduce unfamiliar foods, like leaf concentrate, into people's diet. This is especially true in traditional cultures. It is not impossible, however, and it gets easier every year. One need only to look at the phenomenal popularity of Coca-cola and Pepsi-cola worldwide to recognize that new foods are being adopted by traditional cultures. These foods are heavily promoted by powerful multinational corporations and their popularity is a testament to the effectiveness of advertising.

Sometimes the changes in diet are economic in nature. In Nicaragua rice has been the primary grain for many years. However, as the economy continues to declines there, people are eating far greater quantities of corn because it is cheaper, and they can no longer afford the preferred rice. At the same time refugees returning to Nicaragua from the United States have brought with them a taste for many of the convenience foods that are popular in the US. Pizza, in particular, has experienced great popularity and dozens of pizza shops have sprung up to supply this demand for a new food.

People all over the world are in the process of making dietary changes that are powered by the increasingly rapid movement of people and information among different cultures. Many times this appears to be exploitative and one sided, as when one watches barefoot malnourished children buying soft drinks from foreign companies. Other times it has a more progressive side. Mexican people are eating less lard than they did ten years ago because they have been educated about the links between high animal fat consumption and heart disease and cancer. Even in small villages this information is arriving and people are taking action.

Ultimately whether leaf concentrate is accepted in a given society will have to do with three things:

1. promotion - can leaf concentrate foods be packaged and sold in a way that attracts food buyers?
2. economics - can leaf concentrate be made and sold at a low enough price to be an affordable alternative to other available foods?
3. education - can people be adequately educated in the value of good nutrition in their lives to make changes in diet based on that information?

"Aren't there other alternative high nutrition foods, like soybeans, that would be easier to introduce than leaf concentrate?"
Mention must be given in this manual to the combination of leaf concentrate and soybeans. While soybeans are an ancient crop in much of Asia, in many developing countries they are being promoted as a new low cost diet improver for malnourished people. Leaf For Life is working with groups trying to introduce soybeans in both Mexico and Nicaragua. The biggest advantage of soybeans is that they can often be purchased in bulk and stored for use when needed, whereas leaf concentrate requires fresh cut leaves every day. Soybeans are often a cheaper source of protein than leaf concentrate, but LC is usually a cheaper source of iron. Leaf concentrate is the best known source of beta-carotene while soy has almost none. Together they are quite a nutritional package, and there is no reason why people should have to chose one over the other.

Both leaf concentrate and soybeans make very efficient use of land resources. The chart below compares protein yield of leaf concentrate from alfalfa and soybeans to some other foods.

<table>
<thead>
<tr>
<th>FOOD</th>
<th>Kgs Edible PROTEIN per Hectare in 6 Month Growing Season</th>
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<tbody>
<tr>
<td>Leaf Concentrate</td>
<td>1070 kg</td>
</tr>
<tr>
<td>from Alfalfa</td>
<td></td>
</tr>
<tr>
<td>Soybeans</td>
<td>660</td>
</tr>
<tr>
<td>Wheat</td>
<td>475</td>
</tr>
<tr>
<td>Milk</td>
<td>430</td>
</tr>
<tr>
<td>Eggs</td>
<td>140</td>
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<tr>
<td>Pork</td>
<td>100</td>
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Soybeans have nearly twice the protein and much more oil than ordinary beans. One of the things we like best about soybeans is that a very good milk substitute, called soymilk, can be made in a lot of places where children can't afford, or can't digest cows' milk. We have found an extraordinary nutritional package can be delivered in a single portion by mixing together a glass of soymilk with a tablespoon of leaf concentrate and sugar to taste. One glass of this drink can supply a 4-6 year old child with more than 100% of the vitamin A, 83% of the iron, and 37% of the protein suggested by the US Recommended Dietary Allowances.
Cowpeas, alfalfa and soybeans are all legumes that can convert nitrogen in the air to a form that plants can use. This eliminates the need for expensive nitrogen fertilizer. Besides being a big expense for the farmer, nitrogen fertilizer is also very hard on the environment because it uses tremendous amounts of electric energy to produce and it often is responsible for the pollution of ground water with nitrates in agricultural areas.

One of the reasons that leaf concentrate and soybeans make such a good combination is that much of the equipment we use, especially the 5 gallon blender and press tables, works equally for making soymilk. This keeps the equipment costs for both nutritional products very low. Dried soybeans have an advantage over leaf crops in that they store quite well. In areas where leaf crops are not abundantly available all year, we find that soybeans can be used to bridge the gap. Because the process of making soymilk or soycheese (tofu) are so similar to that of making leaf concentrate, it is easy to train health workers to make both products in the same workshop. Then, instead of shutting down when leaf crop is in short supply, the program can switch to soymilk or tofu and the children can continue receiving a nutritious boost to their diet.

"Isn't hunger caused by political inequality? If it is how can a technical approach, like leaf concentrate, help?"

Many influential writers on the subject of world hunger feel that the problem will never be resolved until people recognize that it is primarily a political problem. Susan George delineates this view when she describes "... hunger as a function of poverty and poverty as a function of fundamentally inequitable power structures both within and between nations." From this point of view measures taken to increase food supply such as irrigation schemes, integrated pest management, and post-harvest food processing, are irrelevant to assuring enough that everyone has enough to eat. This outlook has lost some of it appeal as the socialist governments of the world have come undone, and the prospects for revolutionary redefinition of power structures in favor of the poor have greatly diminished.

The criticism of technical approaches to the issue of hunger frequently relates to failures of the "Green Revolution". This is seen as the imposition of technical innovations, mainly in the form of high yielding seed varieties, that did dramatically increase food supply but did little to reduce the number of hungry people. The new seeds changed land tenure patterns and levels of bean consumption at the same time that they increased the supply of rice and wheat. There are always unintended effects, both bad and good, from new technologies.

Technical changes don't take place in a vacuum and both the scale of operations and the choice of operators have implications for the power relationships in the communities affected. The introduction of leaf concentrate technology can be done on an industrial commercial scale, on a domestic scale, or on a cooperative village scale. Leaf for Life tries to gear its projects so that they can be controlled by women who are generally
disempowered within current social structures in developing countries. We normally advocate small decentralized production units that can remain under local control.

In the long run it will be very difficult to eliminate hunger without fundamentally addressing the inequities of power. It will be equally difficult to eliminate poverty without the introduction of improved food production and processing techniques. The challenge is to develop technologies that don't reinforce the current power structure and to use them as soon as possible to make sure children alive today won't have to wait for big political changes to get enough to eat.

SECTION VI

GENERAL INFORMATION

TROUBLE SHOOTING

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>POSSIBLE CAUSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>leaf concentrate has strong or bitter flavor</td>
<td>- old leaves were used</td>
</tr>
<tr>
<td></td>
<td>- inappropriate species</td>
</tr>
<tr>
<td></td>
<td>- old leaf concentrate (over 2 days refrigeration or 5 days with)</td>
</tr>
<tr>
<td></td>
<td>- delay in processing after leaf harvest</td>
</tr>
<tr>
<td></td>
<td>- some fermentation (no more than 4 hours advisable)</td>
</tr>
<tr>
<td></td>
<td>- advisable</td>
</tr>
</tbody>
</table>


- residual liquid or 'whey' not well enough pressed out
- curd burnt during heating of juice

**leaf concentrate is too moist or wet**
- curd not pressed firmly enough
- curd not pressed gradually enough
- filter cloth is too fine
- juice stirred too much during heating
- juice heated too slowly, making very small curds that clog the filter cloth

**leaf concentrate has a gritty texture**
- leaves not washed well enough before grinding and contain dirt and dust
- some species, like spinach have crystalline oxalic acid that gives the curd a gritty texture.

**leaf concentrate has a fibrous texture**
- juice was not filtered before heating

**low yield of leaf concentrate (less than 5% of leaf weight)**
- old leaves
- very young leaves
- very high water content in leaves or they are wet when weighed from rain or from washing
- leaves not ground up well
- juice not pressed well enough from fiber
- juice not heated high enough to coagulate curd

All the processing is going too slowly.

- too much time is being spent sorting and leaves. Extreme care is not needed.
- leaves are being hand stripped from stalks
- workers are waiting for one step to be finished before beginning the next step. (Usually it is good to have one worker grinding while another presses)
- workshop is not arranged efficiently
- tables are too high or too low for working
- socializing among workers or friends and has become too distracting
- children are interfering with work in the workshop

Leaf juice is taking too long to heat.

- pressure is too low on gas stove
- flame is too far below pot
- flame only in contact with part of pot
- breeze on flame and pot
- if wood fire is used; wood is wet or not well enough split up. It may need more air supplied by a small fan.
- Cook pot is too deep

- metal of pot is too thick

- no top on pot

**leaf juice burns on pot bottom**
- juice left on heat after it reaches boiling point
- flame not evenly spread over bottom of pot
- pot not cleaned well enough after a previous burn
- lack of gentle stirring during heating

**grinder or macerator motor not running**
- not fully plugged in
- outlet linked to light switch that is not turned on
- circuit breakers off or fuse burnt out
- reset button on motor needs to be pushed
- damaged or wrong size seal has allowed water to pass from blender into motor

**grinder or blender running too slowly**
- motor wired for 220 volts on 110 line
- motor wire for 60 Hertz running on 50 Hz
- too many leaves in blender
- too little water
- leaves not cut into short enough pieces
<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>meat grinder not grinding leaves well</td>
<td>- leaves not cut in short enough pieces</td>
</tr>
<tr>
<td></td>
<td>- leaves are too wet; juice is filling grinder</td>
</tr>
<tr>
<td></td>
<td>- motor shaft and grinder shaft are not aligned or connected</td>
</tr>
<tr>
<td></td>
<td>- blade is not in place or is in backwards</td>
</tr>
<tr>
<td></td>
<td>- holes in die plate are too small or too few</td>
</tr>
<tr>
<td></td>
<td>- motor speed is not reduced enough or is too much; should be between 60-90 RPM</td>
</tr>
<tr>
<td>children are not showing</td>
<td>- not enough leaf concentrate is being given</td>
</tr>
<tr>
<td>improvements in health</td>
<td></td>
</tr>
<tr>
<td>after 4 months on leaf concentrate program</td>
<td></td>
</tr>
<tr>
<td>per day</td>
<td>- leaf concentrate meals are too irregular</td>
</tr>
<tr>
<td></td>
<td>- children are not eating all the meal that is offered</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- leaf concentrate food is being shared with family members</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- child is not malnourished</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- child is not receiving the usual amount of food at home.</td>
</tr>
</tbody>
</table>
- intestinal parasites or other chronic health
SAFETY

Machinery
- Children should be kept away from machines in use.
- Machines should be unplugged when not in use, when being cleaned, or when being repaired.
- Electric cords should be kept out of water and out of foot traffic.
- Switches should be within easy reach of machine operators.
- Motors should be equipped with manual reset buttons to prevent accidental restarting after they shut off from an overload.
- Guards should always be used to keep hands out of moving machinery. Wooden push rods should be used to feed leaves into the blender or grinder.
- Ear protection should be worn if the noise level from the machines is very high.

Cooking with Gas
- Gas cylinders should be tied or chained in an upright position.
- Make sure all connections are tight and there are no leaks. Use Teflon tape if available. Test connections with a little soapy water. This will let you know if there is a leak.
- If possible, have the gas tank outside, with only the tube or hose inside.
- Don't use a gas cooker in a small unventilated room.
- Make sure gas is turned completely off before leaving workshop.
- Any flame should be at least 2 meters away from the gas tank. Further is better.
- Keep tubes, hoses and connections as out of the work area if possible to avoid people tripping on them.

General Safety
- Use normal precautions when dealing with large pots of hot liquids.
- Get help if you need to move something heavy. Lift with your legs not your back. Don't risk hurting your back.
- Keep floors free from wet areas if possible, especially around machinery.
- Wear footwear with good footing rather than going barefoot or wearing loose sandals.

HYGIENE

- All workers should wash their hands well before handling food.
- Animals should be kept out of the work area.
- Workers who are coughing or sneezing should not handle food.
- Equipment should be well cleaned after each use. Pulped leaves, leaf juice, and leaf concentrate can all ferment quickly if left on machinery.

Diseases Transmitted by Food
Diarrhea is the largest cause of death in children. Worldwide an estimated four million children under the age of five die each year from diarrhea. The symptoms of food transmitted disease are usually diarrhea and sometimes nausea and cramps following the consumption of food or water that is contaminated. There are two types of food borne diseases. Intoxication is when a person is poisoned by toxins produced by microorganisms living in food before it is eaten. Infection is caused when living microorganism in food multiply after they reach the person's digestive tract. Young children and people with lowered immune system resistance are those most likely to die from food borne disease.

The types of bacteria responsible for intoxication diarrhea are not normally present in leaf concentrate processing and should not be a problem in LC programs. Many of the worst agents of infection are thrive mainly on meat, poultry and seafood. Some of the bacteria that can cause infections in the human digestive system are present in the soil and throughout the tropical environment. These include shigella, listeria, E. coli, Staphylococcus aureus, and Bacillus cereus. Fortunately all of these are killed by heating to boiling as is done with the coagulation of leaf juice. The main danger of bacterial infection from leaf concentrate comes from it being recontaminated after it is pasteurized.

To avoid this it is important to store the leaf concentrate in very clean containers and either refrigerate it or dry it as soon as possible after it is pressed. If it is to be stored for more than a day or so without refrigeration it should be resuspended in an acidic wash water to lower the pH below 4.5. This should be done with a diluted acid, if it is necessary. Moist leaf concentrate should be eaten within a week even if it is refrigerated.

**LEAF CONCENTRATE: SOME BASIC RELATIONSHIPS**

**LAND AREA**
1 hectare = 100 meters (327 feet) on a side or c. 107,000 square feet or c. 21/2 acres.

1 acre = c. 64 meters (c210 feet) on a side or c. 43,000 square feet or .4 of one hectare

(Nicaragua) 1 Manzana = c. 80 meters (265 feet) on a side or c. 70,000 square feet or .7 hectare or 1.6 acres.

**WATER REQUIREMENTS** Rapidly growing green crops usually need between 3-4cm (1-1 1/2 inches) of water per week for top growth, depending on soil, air temperature, and humidity.

or 60-90 gallons per 100 square feet or 65,000 - 97,000 gallons per hectare per week or 26,000 - 39,000 gallons per acre per week.

**GREEN CROP YIELD** Highly variable. Probably 3-5 kg per square meter (2/3 - 1 lb per square foot) per year is a reasonable estimate for our use. 35-50,000 kg per hectare;
or 30-45,000 lbs per acre (1kg = 2.2 lb). This comes out to about 100 kg a day per hectare or about 100 lbs a day per acre. Triple these yields are sometimes achieved under intensive conditions.

**TYPICAL YIELD OF LEAF FRACTIONS**

- 100 kgs leaf crop, ie. alfalfa or cowpeas (18-20 kg dry matter)
- 4-7 kg LC at 60% moisture (1.5 -2.5 kg dry matter)
- 45 kg fiber at 70% moisture (c. 13.5 kg dry matter)

**COMPOSITION OF LEAF CONCENTRATE**

100 gr of 60% moisture LC should contain approximately:

- 24 gr **Protein** (High quality protein equivalent to meat or fish, lower than milk or eggs, better than grains, or beans).
- 50,000 IU **Vitamin A** (As beta-carotene)
- 40 mg **Iron** (This is an average of 20 samples worldwide. Actual amount will vary greatly with soil and processing equipment).
- 720 mg **Calcium**
- 140 **Calories**
- 140 mcg **Folic Acid**

**USRDA for 4-6 year old children:**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>30 g</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>2500 IU</td>
</tr>
<tr>
<td>Iron</td>
<td>10 mg</td>
</tr>
<tr>
<td>Calcium</td>
<td>800 mg</td>
</tr>
<tr>
<td>Calories</td>
<td>1800</td>
</tr>
<tr>
<td>Folic Acid</td>
<td>200 mcg</td>
</tr>
</tbody>
</table>

- see section on nutrition -

**MISCELANEOUS RELATIONSHIPS**

1 kg fresh leaves should yield 1/2 liter or 1 pint juice.

1 tablespoon fresh LC = c. 15 gr. or 1/2 oz.

1 kg LC will provide 66 portions of 15 gr. each
1 pound LC will provide 30 15 gr. portions.

For daily portion of 15 gr., figure c. 30 square meters (300 square feet) of good land per child.

1 pound LC will provide 18 25 gr. portions.
1 kg LC will provide 40 portions of 25 gr. each.

To provide a daily portion of 25 gr., figure 50 square meters (650 square feet) of good land per child.

On Dry Weight Basis: LC should be 50-65% protein, 20-25% lipids, 5-9% ash, .8-1.0% beta-carotene with significant amounts of calcium, xanthophyll, iron and vitamin E.

**FEED VALUE OF FIBER** When figured on a dry weight basis, the fiber left over from leaf concentrate processing has approximately the same feeding value to animals as unprocessed fresh leaf crop. Because fresh alfalfa and other leaf crops are usually around 20% dry matter, while the residual fiber is around 30% dry matter; the fiber has about 1½ times the feeding value, per kilogram, as the leaves that it was made from.

The fiber remaining from processing one ton of alfalfa should provide the bulk of the forage requirement for 25-30 cows who can produce about 75-100 liters of milk daily. If we assume a daily ration of 2 kg dry matter for every 100 kg cow weight, this 45 kg of fiber will feed two and a half 300 kg cows. The 100 kg of unprocessed leaf crop would feed three and a third cows of the same weight.

**WHEY** Whey is rich in nitrogen and potassium but deficient in phosphorus as a fertilizer. It is not acceptable in human diet because of concentrations of nitrates, oxalic acid, and other anti-nutrients. It has been remixed with the fiber for cows with good results, though watering pigs with whey has led to kidney problems over time. 10 liters whey will cover 1 meter sq. 1 cm deep. 2-3 cm per week may be needed to supply optimum water. This amount may damage seedlings and some plants. Diluted whey, as in that from blender processed leaf concentrate, is safe for plants. It is best used for high value crops near processing site.

- see section on by-products -

**YIELDS OF LEAF CONCENTRATE**
### VS CROP MOISTURE

<table>
<thead>
<tr>
<th>Crop Moisture Content (%)</th>
<th>Yield of Fresh Leaf Concentrate (60% moisture) (grams fresh LC per 100 grams of crop)</th>
<th>DM yield</th>
<th>DM yield</th>
<th>DM yield</th>
<th>DM yield</th>
<th>DM yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>15% DM yield</td>
<td>9.38</td>
<td>7.81</td>
<td>6.25</td>
<td>4.69</td>
<td>3.13</td>
</tr>
<tr>
<td>80</td>
<td>12.5% DM yield</td>
<td>7.5</td>
<td>6.25</td>
<td>5</td>
<td>3.75</td>
<td>2.5</td>
</tr>
<tr>
<td>85</td>
<td>10.0% DM yield</td>
<td>5.63</td>
<td>4.69</td>
<td>3.75</td>
<td>2.81</td>
<td>1.88</td>
</tr>
<tr>
<td>90</td>
<td>7.5% DM yield</td>
<td>3.75</td>
<td>3.13</td>
<td>2.5</td>
<td>1.88</td>
<td>1.25</td>
</tr>
</tbody>
</table>

**Grams of dry LC per 100 grams of crop dry matter**

<table>
<thead>
<tr>
<th>Grams of dry LC</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than 15 grams</td>
<td>Excellent Yield</td>
</tr>
<tr>
<td>12.5 to 15 grams</td>
<td>Very Good Yield</td>
</tr>
<tr>
<td>10.0 to 12.5 grams</td>
<td>Good Yield</td>
</tr>
<tr>
<td>7.5 to 10.0 grams</td>
<td>Fair Yield</td>
</tr>
<tr>
<td>Less than 7.5 grams</td>
<td>Poor to Very Poor Yield</td>
</tr>
</tbody>
</table>
### RELATIONSHIPS BETWEEN
YIELDS OF LEAF CONCENTRATE AND FIBER
AND CROP MOISTURE CONTENT

<table>
<thead>
<tr>
<th>Moisture Content of crop</th>
<th>Product</th>
<th>7.5%</th>
<th>10.0%</th>
<th>12.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>80%</td>
<td>leaf concentrate</td>
<td>5</td>
<td>6.7</td>
<td>8.3</td>
</tr>
<tr>
<td></td>
<td>fiber</td>
<td>55</td>
<td>51.7</td>
<td>49</td>
</tr>
<tr>
<td>85%</td>
<td>leaf concentrate</td>
<td>3.8</td>
<td>5</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>fiber</td>
<td>41.3</td>
<td>39</td>
<td>36.7</td>
</tr>
<tr>
<td>90%</td>
<td>leaf concentrate</td>
<td>2.5</td>
<td>3.3</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>fiber</td>
<td>27.5</td>
<td>26</td>
<td>24.5</td>
</tr>
</tbody>
</table>
Note: Both leaf concentrate and fiber assumed to be at 70% moisture. Leaf concentrate should be pressed to 60% moisture whenever possible.

Walter Bray February 1993

SOME RULES OF THUMB

1. **IF IT SMELLS BAD, IT IS Bad.** This applies to leaves, LC, and products made from LC.

2. If you can recognize pieces of leaf in the pulped leaves, they probably aren't ground up enough.

3. If you take a pinch of fresh green leaf and rub it vigorously between your thumb and forefinger it should produce a thin green watery juice. If there is no juice or the juice is sticky, it is not a good choice for making LC.

4. If you can squeeze juice from the fiber with your bare hand after it has been pressed it is probably over 70% moisture and not well enough pressed.

5. If you take a pinch of fresh LC and smear it with your thumb across your palm, it should roll back up and leave your palm clean. If it goes on like finger paint and leaves your palm green it is too wet; probably 70% moisture or more.

6. **If you are getting a 10% yield you are probably doing something wrong.** If 100 kg of fresh leaves is producing more than 7 kg of leaf concentrate, chances are it is very wet LC. Normally 5% is typical, don't feel bad if you are getting 5% and reading about others getting 10%; reality is on your side. The same is true with dry yields over about 2.5%.

7. **Nothing changes the economics of LC as greatly as wet curd.** Assume you are yielding 2% on a dry basis, and you are processing 200 kg of leaves and selling fresh LC for $4 per kg. If your curd is well pressed (60% moisture) you will get $40 worth of LC. If your curd is poorly pressed (75% moisture) you will have $64 worth of curd. Of course, the difference is that you are selling 6 liters of water for $24. This is a tremendous temptation, but a death threat to LC projects. It is why we increasingly recommend using dried LC.

8. **Averages are humbling things.** If you normally produce 4 kg of dry LC per day of work, but on average you don't process one day a week because of electric problems, average production is 3.2 kg not 4. If the shop is closed for Holy week, two weeks at
Christmas, whenever there is a storm, whenever a worker has a sick relative, and whenever you are out of leaves or a machine needs repair, the average daily production over the year may be only 2 kg.

9. Wholesale prices are lower than retail. If you see noodles for sale in a health food shop for $2.00 per kg, this does not mean that the producer of the noodles receives $2.00. More likely he gets $1.00 and the store owner and other middlemen get the other one.

10. There is always some waste. If you are making syrup you will end up with half a bottle left over. If you make churritos some will burn or break. If they are well made some will get eaten in the shop before being packaged.

COMMUNICATIONS

An important part of any leaf concentrate project is communications. A few suggestions on communications from my experience with leaf concentrate projects.

Learn the local language.
Every field worker I've talked to that has worked in Latin America wishes that he had spent more time learning Spanish before going there to work. The same is likely true of other languages. Every bit helps; whether its high school courses, language tapes, a short intensive course in a foreign country, or just studying a phrase book. Keep studying after you've arrived in a foreign country. Use the language even if you don't speak gracefully. Avoid hanging out exclusively with ex-patriates who speak your language. That will slow the learning process down.

Use terms that are as universal as possible.
Your reports from the field are of great interest to a range of people working with leaf concentrate in countries all over the world. Using scientific as well as local names for crops, weeds, insects, foods etc. that are not commonly known worldwide will increase the value of your information. I'm frequently frustrated by reports on crops or recipes from India that use local names unknown to me. Sometimes I can look them up, because I have access to good libraries, but this is a time consuming and often fruitless labor. Other workers in developing countries are less likely to be able to look up these names and thus these reports are often worthless as a result. Usually someone at a local agricultural school will know the scientific names of plants and pests important in that region.

The same holds true with the use of local currencies and measuring systems. People don't have any idea how big a field of 10 Indian bighas or 6 Nicaraguan manzanas is outside of those cultures. Detailed economic analysis in local currency without reference to an exchange rate to one of the larger currency systems like the US $ or British £ can also be worthless. In general we should include metric system measurements as well as local ones in any reporting.
Use standard field tests whenever possible. For example, the percentage of dry matter in leaves compared to the percentage of leaf concentrate dry matter from those leaves, provides a lot of good information about a crop and how likely it is to be a useful plant for making LC. Tests that use fresh weight without giving the percentage of moisture in either the leaves or the LC provide far less information.

Work toward high speed low cost computer links. Electronic information networks, like Eco-Net, and PeaceNet, are opening up possibilities to exchange information quickly and inexpensively worldwide. We need to move towards these types of systems as telephone calls are very expensive and the voice quality often bad, and mail is too slow between projects and office. Frequently there is a month or more lag between correspondence and questions asked don't get answered. If we could develop a somewhat standardized format one could respond by saying something like "please clarify point 3 in report # 256". The linking of the actual field situation with the experience and resources of the home offices is frequently quite weak.

Use a standardized monthly production report for each project. Monthly reports on production provide very valuable information and help us identify problem areas quickly. A sample monthly report form that can be copied is in the appendix of this manual.
CONSIDERATIONS IN SETTING UP PROJECTS

The following list of questions may seem very long. It is not necessary to answer them all in order to be able to run a leaf concentrate project, but they give a good idea of the many factors that can affect the success or failure of such project. Generally, the more thought that goes into these types of questions before a project is set up, the greater the likelihood of success.

**Agricultural**
- Are there any commercial crops currently grown in the area that could be used for LC production?
- Rainfall information. How much? What months?
- Is sufficient land available to grow leaf crops? Not too steep or very rocky?
- Are tractors available to work the land? Crops like cowpeas that are frequently replanted need easy access to tractors or animals or roto-tillers to prepare soil. Beware too easy yes answers.
- How hot is it in the hottest season? When and for how long?
- What are the main crops now grown in that area?
- Any information on yields of corn, sorghum, alfalfa etc is helpful for estimating land requirements for other LC crops. Get more than 1 opinion.
- Any information on land prices per hectare of farmland? Irrigated farmland?
- Rental or lease agreements used for land tenure?
- Market prices and seasonal availability of forages and animal feeds, especially dairy feed.

**Nutritional**
- Evidence of malnutrition in children. Any available weight for age, weight for height or height for age data.
- Night blindness in children?
- Anemia in children under 5 and pregnant women?
- General impressions of frequency and severity of diarrhea, respiratory infections and measles?
- Seasonal fluctuations in these?
- Do other feeding programs exist in the area? Are other agencies and organizations active?

**Dietary**
- What percentage of the children are breastfed? To what age on average?
- Are any greens eaten regularly by children?
- Carrots?
- Orange fruits or vegetables?
- Impressions of consumption of meat, fish, eggs and milk?
- Is milk vitamin A fortified?
- Prevalence of home gardens?
- What is grown?
- Availability of greens in local stores?
- What do women perceive as shortcomings in their diet? ie "If you had $10 more a week to spend what foods would you buy more of?"?
- Snack food patterns?
- Are there any important food taboos, especially for childrens food?

**Economic**
- Wages or income of agricultural workers?
- Seasonal fluctuations in family income?
- Income generating activities for women? ie. assembly plants, home crafts, field work?
- What can they earn in 4 hours? This plays a big role in how women will evaluate economic potential of LC project.
- Price per kg of staple foods at local stores.
- What cook fuel is used? Cost per month per household?
- Estimated cost of food as percentage of income?
- Is there an apparent market for LC or must one be developed?
- Is there an apparent market for the fiber or must one be developed?

**Building for Leaf Concentrate Workshop**
- How far is building from the fields of leaves?
- Over what type of roads or path?
- Will leaves be hauled by wheelbarrow, bicycle, horse cart, truck?
- How big is the building or room?
- Who owns it?
- What competing uses are there for the building?
- Can equipment be secured against theft or vandalism?
- How easy is it to clean?
- What is the electric capacity in the building?
- Is running water available? Drinking quality?
- Is building screened to keep out insects?
- Can processing and feeding be done in same building?
- Is there a good drainage system? A sanitary toilet

Machinery
- Are there qualified people involved in the project who can do basic machinery work?
- Welding?
- Carpentry?
- Installing gas cooking equipment?
- Can a college level technical or agricultural school be integrated into program?

Use of By-products
- Are there goats, rabbits, sheep, or cows that can be integrated into the project within wheelbarrow distance of processing center?
- Are there crop fields near enough the workshop to haul whey in buckets for fertilizer?
- Are there any bio-gas programs nearby?
- Are mushrooms commonly eaten in the area?
- What is the cost and availability of off season cattle feed? Hay?
- Cost per hectare of urea or other nitrogen fertilizer for corn, or sorghum, or other basic grains?

Organizational
- Brief history of partner organization and its leading characters.
- How will LC be distributed?
- Will an existing distribution system be used or a new one created?
- Is motivation primarily nutrition intervention, income generation, or some other factor?
- Will leaf concentrate be sold or given away?
- If sold who will get the money?
- How many children will receive leaf concentrate?
- Will the children come to a central feeding center or will the leaf concentrate be delivered to the homes of the children?
- Are there records available of childrens' names, ages, height and weight?
- Will pregnant and nursing mothers receive leaf concentrate?
- How are mothers involved?
- Will workers be volunteers on rotation?
- Is there any paid staff?
- Is there a contact person for your group that can be reached by phone?
- Other national or international agencies that co-operate with or finance this organization.
Names and addresses of contacts for these

Financial
- How do people envision financing project?
- Estimation of set up costs?
- Estimation of yearly operating costs?

Transportation
-How long does it take to get to the nearest large town by bus? Cost? Frequency of buses?
-How long does it take to get to the nearest large city?

**Miscellaneous**
- Are indigenous people involved in the design and management of the project?
- Is the local political leadership enthusiastic about the project?
- Are there any people who are hostile or very suspicious of the project?
- Are there related projects that might feel threatened by a leaf concentrate project?
- Or that might become integrated with one?
- Is the project leadership closely tied to one political party or other group such as a church that may make segments of the local population reluctant to participate?

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**RECIPES**

These recipes are offered simply to give an idea of the many ways in which leaf concentrate can be prepared in different cultures. Recipes are always adjusted to local conditions of taste and availability of ingredients. We would love to hear of any new recipes or variations on these that you think are good. Each of these recipes provides far more essential nutrients to the body than the traditional recipes on which they were based. The addition of leaf concentrate can turn an ordinary food into a nutritional powerhouse.

**Basic Leaf Concentrate Syrup formula**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>375 ml water</td>
<td>12 fluid oz</td>
</tr>
<tr>
<td>1 kg 60% moisture LC</td>
<td>2 lb</td>
</tr>
<tr>
<td>2 kg sugar</td>
<td>4 lb</td>
</tr>
<tr>
<td>30 g salt*</td>
<td>25 g</td>
</tr>
<tr>
<td>1.7 g ascorbic acid**</td>
<td>1.5 g</td>
</tr>
</tbody>
</table>

Mix well in blender. Approximately 15 grams LC per 30 ml (fluid oz).

**Lemonade Concentrate Syrup**

1 liter lemon juice
2 kg (3.3 lbs) sugar
1 kg (2.2 lbs) moist leaf concentrate*
50 ml lemon extract (if available)
Blend the leaf concentrate at the highest speed in the lemon juice and extract. Gradually add the sugar and continue blending until very smooth. This syrup can be put in a bottle with a tight fitting top and stored for later use. Mix two tablespoons of the syrup in a large glass of water, or a half liter of syrup in 2 gallons of water.

note: Lemon extract can be replaced by lemon oil or 50 grams finely ground lemon peel. Limes can be used instead of lemons.

* Dried leaf concentrate does not work well in thin liquids like lemonade. Even with using moist leaf concentrate some of the solids will settle so it is a good idea to stir up the drinks immediately before serving.

**Pasta**

3 - 4 kg (6 1/2 - 9 lbs) wheat flour
1 kg (2.2 lbs) moist leaf concentrate or 400 gr dry
2 tablespoons salt

Mix flour and salt, then add leaf concentrate and a small amount of water. Knead for 10 minutes. Dough should be very heavy but elastic. Roll the dough out as thin as possible and cut into strips. These can be cooked as is or dried in a dark room, sealed in a plastic bag and cooked when convenient.

note: Hand operated stainless steel pasta rollers are available in some gourmet cook shops for about $50 US. They make very uniform pasta.

**Soup Nuggets**

1 kg (2.2 lbs) wheat flour
2 kg (4.4 lbs) moist leaf concentrate or 800 gr dry
100 g (3 1/2 ounces) salt
flavorings to taste

Mix the salt, flour, and flavorings together and then add the leaf concentrate to make a dough. Roll the dough out in a layer about 1/2 cm thick. Cut into small squares. These squares can be dried, then added to rice or soups or stews. They can also be cooked in boiling water for 3-5 minutes before being dried. In that case they will need no further cooking. When they are well dried they will store well if sealed and kept from sunlight.

note: powder, chili, mustard, horseradish, garlic, onion ginger, or other strong spices can be used to make nuggets that will add flavor and nutrition to any cooked dish.

**Atol (Latin America)**

1 kg (2.2 lbs) corn (maize) flour
1 kg (2.2 lbs) bananas
1 kg (2.2 lbs) moist leaf concentrate or 400 gr dry
250 grams (1/2 lb) sugar

To a mixture of corn flour and sugar, add water and cook for 10 minutes. Mash bananas and leaf concentrate together and add mixture to the cooked flour. Mix thoroughly. Remove from heat and serve in bowls.

Note: Atol can be made as a hot thick drink or as a very thick pudding or pastry filling, or depending on how much water is used. Many people prefer atol made with corn starch as it is smoother in texture.

**Porridge***

- 2 kg (4.4 lbs) ragi flour (millet or sorghum)
- 1 kg (2.2 lbs) rice
- 1/2 kg (1.1 lbs) brown sugar
- 1/2 kg (1.1 lbs) moist leaf concentrate or 200 gr dry

Cook the rice, ragi flour, and sugar for 15 minutes in enough water to make a fairly thick porridge. Thoroughly mix in the leaf concentrate and serve warm.

Note: This basic porridge can be made with any locally available grain or with starchy roots like cassava or potatoes.

**Porridges as Weaning Foods**

Both atol and porridges are frequently used as weaning foods for infants. The addition of leaf concentrate to the traditional porridges can make a tremendous difference in the health of infants during this time of extreme nutritional vulnerability.

A very serious problem with porridges as weaning foods is that young children usually don't get enough calories and nutrients from the volume of porridge they will eat. This is because the nutrient density, or amount of essential nutrient per volume of food, is too low. If parents try to increase the nutrient density of the porridge by adding more solids it becomes very thick and gloppy and the children will eat less of it. If the porridge is made thinner with more liquid, children will consume a larger volume but most of the difference is simply water, so the intake of nutrients is about the same. The nutrient density can be improved by adding leaf concentrate, and oil, or sugar.

An alternative strategy involves breaking up the starch bonds that make porridge thick and gloppy. This can be done by adding 5 - 20% flour from sprouted corn or sorghum. These sprouted grains are rich in amylase which breaks the starch bonds and makes the porridge more liquid. By using these sprouted grains much more flour can be added to the porridge which increases the nutrient density up to three times. The amylase is inactivated at temperatures above 70 degrees C. (160 degrees F.) so the sprouted grain flour needs to be added to the porridge after it has cooled a bit.

The grains should be washed then soaked 8-10 hours in clean water. After that they need to be left in a warm dry place and rinsed twice a day for three days. The sprouted grains...
are then sun dried. When they are very dry the grains should be rubbed between your hands to remove all the root hairs and shoots. **THIS IS VERY IMPORTANT WITH SORGHUM BECAUSE THE VEGETATIVE PORTIONS OF SPROUTED SORGHUM GRAIN CONTAINS TOXIC HYDROCYANIC ACID. DO NOT EAT SPROUTED SORGHUM WITHOUT CAREFULLY REMOVING THE ROOT HAIRS AND SHOOTS.** White sorghum works far better than brown or purple types of sorghum. I recommend using sprouted corn to avoid any danger from sorghum. After the sprouted grains are fully dry they can be ground like any other grain. The amylase activity of the sprouted grain flour gradually diminishes with time, so it should be used within two weeks of when it is sprouted. While this may be extra work, in many areas grain sprouting is already widely practiced at the household or small business level, for various reasons including the brewing of beers.

**Soymilk Shake**

- 250 ml (1 cup) moist leaf concentrate or 100 ml dry
- 2 1/2 liters soymilk (or cows' milk)
- 1 1/4 sugar
- 2 tsp vanilla extract or flavoring.

Blend the leaf concentrate well in 1 liter of soymilk, then blend the sugar well with another liter of soymilk. Mix these two and the remaining soymilk together well in a large enough container. Makes 10 glasses.

**Frozen Snack**

- 250 ml (1 cup) moist leaf concentrate or 100 ml dry
- 250 ml (1 cup) sugar
- 2 bananas
- 1250 ml (5 cups) soymilk (or cows' milk)

Blend all the ingredients together well. Pour into 10 small plastic bags and tie firmly closed, then freeze. These can be removed from the bags and eaten with a spoon, or they can be sucked through a hole bitten in the corner of the bag.

**Laddu** (India)

- 1 kg flour
- 1 kg brown sugar
- 1 kg moist leaf concentrate or 80 grams dry
- 200 grams vegetable oil

Dissolve the sugar in a little water; add the flour and oil. Cook for 15 minutes. Mix in the leaf concentrate and let cool to near room temperature. Form the mixture into little balls (about 25 g each). These can be rolled in sugar if desired. Note: any locally available flour can be used to make the laddu. Flavorings like ginger can be added as can chopped nuts or fruit.
**Tortillas** (Mexican and Central American corn flatbread)

- 1/2 kg corn flour
- 100 g wheat flour
- 100 g moist leaf concentrate or 40 grams dry

Mix all the ingredients and knead for 5 minutes. Form small balls and press flat by hand or with a wooden or metal tortilla press. Grill on both sides until cooked through. Serves 5 adults or 10 children.

**Tamales** (Mexico)

- 500 ml (2 cups) corn flour (maíz harina)
- 125 ml (1/2 cup) moist leaf concentrate or 50 ml dry
- 2 teaspoons baking powder
- 1 teaspoon salt
- 80 ml (1/3 cup) lard or vegetable shortening
- 1 1/2 cup soup stock or water

Combine dry ingredients. Beat the lard until creamy, then gradually beat in the dry ingredients. Slowly add the soup stock or water, stirring constantly. Spread about 1 tablespoon of this dough in the center of a clean corn leaf. Wrap the dough in the corn leaf by neatly folding in the edges. Repeat until all the dough is wrapped. This should make around 25 tamales. Steam the tamales for 40 - 60 minutes. Serve hot. About 3 per person.

Note: The tamale dough can be flavored with chili or other flavorings, or sweetened. A tablespoon of various types of fillings can also be enclosed by carefully placing it on the center of the dough before it is wrapped.

**Uchepos** (Mexico)

Uchepos are made the same way as tamales except they use a dough made from corn that is not fully ripened or dry. They have a unique flavor and are a traditional dish of Michoacan, Mexico.

**Kola Kenda** (Sri Lanka)

- 500 ml (2 cups) dry rice
- 250 ml (1 cup) grated coconut
- 250 ml (1 cup) moist leaf concentrate or 100 ml dry

Cook the rice and coconut until a thick porridge is formed. Mix the leaf concentrate in thoroughly. Serve warm.

Note: Kola kenda is a traditional dish of Sri Lanka, where it is normally made with fresh green leaf juice. The version made with leaf concentrate is well accepted there.

**Curried Potato Soup**

- 1 1/2 kg potatoes
- 250 ml (1 cup) moist leaf concentrate or 100 ml dry
- 3 medium onions
60 ml (1/4 cup) butter, margarine, lard, or oil
2 tsp curry powder
1 tsp salt
1 tsp dill seed

Peel, cut and boil potatoes. Add onion to boiling water for about 5-10 minutes. Strain and add leaf concentrate, butter, and spices. Blend until creamy, adding more water or milk if needed. Serve hot or cold. Different spices may be used for variations.

**Lemon Trail Bars**

250 ml (1 cup) moist leaf concentrate or 90 ml dry
250 ml (1 cup) sugar
125 ml (1/2 cup) shortening
125 ml (1/2 cup) flour
125 ml (1/2 cup) rolled oats
125 ml (1/2 cup) raisins
1 1/2 tsp lemon extract or grated lemon peel

Mix all the ingredients together well. Spread 1 1/2 cm (1/2 inch) thick layer of mixture on greased cookie sheet. Bake for 40 minutes in slow oven. Slice into bars then let cool. Other flavorings, like almond, can be substituted for lemon.

**Barfi** (India)

50 g LC (fresh)
150 g Bengal gram flour
125 g oil
250 g sugar
50 g potato flour
25 g milk powder
5 - 6 cardamoms

Roast Bengal gram flour in half the oil, add milk powder. Saute potato flour and LC in remaining oil. Mix enough water to sugar to make thin syrup. Add Bengal gram flour and LC mixture to this. Stir constantly while heating. When about to set mix in crushed cardamoms and spread evenly on greased tray. Cut into 20 diamond shaped pieces.

**LC Rice** (India)

1 cup rice
1/4 cup fresh LC
1 onion
3 tablespoons oil
2-3 green chilies
1/2 tsp curry powder
2 tomatoes
1/2 tsp chili powder
salt to taste

Brown onion and curry powder. Add rice and fry for 10 minutes. Add LC, chilies, chili powder and salt and enough water to cook the rice. When rice is half done add tomatoes. Serve hot.

**Tikki (India)**
- 200 g potatoes
- 150 g LC (fresh)
- 50 g potato flour
- 2 Tbsp sugar
- 200 g Bengal gram flour
- 2 onions
- 4 green chilies
- 150 g oil
- 1 tsp curry powder
- 1 tsp garam masala
- salt to taste

Mash potatoes and add LC, potato flour, sugar, garam masala, salt, green chilies, and one chopped onion. Saute remaining onion with half the curry powder. Add LC mixture and cook 5 minutes on low fire. Remove from heat and let cool. Form into 20 balls. Flatten the balls a little and dip them in a light batter made from the Bengal gram flour, the remaining curry powder, salt, and enough water for a light consistency. Fry till crisp. Serves 10 people.

**Tamarind Jelly (Nicaragua)**
- 1 kg sugar
- 250 g tamarinds
- 1 liter water
- 2 Tbsp fresh LC
- 1 tsp. cloves
Soak tamarinds in water. Remove seeds. Slowly cook sugar in water and tamarind extract. Add Cloves and LC. Heat slowly till thick.

**Green Salsa** (Mexico)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>tomatoes</td>
<td>300 g</td>
</tr>
<tr>
<td>onion</td>
<td>1/2</td>
</tr>
<tr>
<td>chili serranos</td>
<td>4</td>
</tr>
<tr>
<td>chili perones</td>
<td>2 small</td>
</tr>
<tr>
<td>LC (fresh)</td>
<td>60 g</td>
</tr>
<tr>
<td>cilantro</td>
<td>1 piece</td>
</tr>
<tr>
<td>garlic</td>
<td>1 clove</td>
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</tbody>
</table>

Cook the chilies and tomatoes for 10 minutes. Add all the remaining ingredients and mix briefly in a blender or with an egg beater or spoon.

**Churritos** (Latin America)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>corn (maize) flour</td>
<td>350 g</td>
</tr>
<tr>
<td>LC (fresh) or dried</td>
<td>125 g</td>
</tr>
<tr>
<td>wheat flour</td>
<td>100 g</td>
</tr>
<tr>
<td>baking powder</td>
<td>1/2 tsp</td>
</tr>
<tr>
<td>salt to taste</td>
<td></td>
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</tbody>
</table>

Mix all the ingredients well. Drive through holes in a meat grinder with the knife removed (.5-1 cm holes). Fry the worm like churritos and serve as a snack.

**Potato - Carrot Pancakes** (Mexico)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>potatoes</td>
<td>3/4 kg</td>
</tr>
<tr>
<td>carrots</td>
<td>3/4 kg</td>
</tr>
<tr>
<td>bread crumbs</td>
<td>1 cup</td>
</tr>
<tr>
<td>eggs</td>
<td>2</td>
</tr>
<tr>
<td>grated cheese</td>
<td>1/4 kg</td>
</tr>
<tr>
<td>LC (fresh)</td>
<td>3 Tbsp.</td>
</tr>
</tbody>
</table>

Wash and peel the potatoes and carrots, then grate them into the same bowl. Mix LC, bread crumbs and salt together. Then mix in the cheese and the beaten eggs. Drop on hot frying pan by the tablespoon and cook like a pancake.

**Swedish Meat Balls**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>fresh LC (or 1/4 cup dried)</td>
<td>1/2 cup</td>
</tr>
</tbody>
</table>
1 cup dry bread crumbs
1 egg
1 onion (chopped)
1 clove garlic (chopped)
1/4 cup peanuts (chopped)
1 tsp salt
1 tsp chili powder

Mix together all ingredients. Form into balls and fry in hot oil till crisp.

**Leaf Burger**

- 375 ml (1 1/2 cups) dried bread crumbs
- 250 ml (1 cup) moist leaf concentrate or 100 ml dry
- 1 egg
- 60 ml (1/4 cup) wheat flour
- 1 tsp mustard
- 1 clove garlic chopped fine
- 1 tsp salt

Mix all ingredients well. Form into flat patties about 8 cm in diameter. Fry these on both sides until they begin to brown. Serve on bun with catsup. This mix can be made into meatless `meatballs' as well, by forming balls instead of flat patties.

**Fiona's Vegan Leaf Burgers**

- 1 cup fresh LC
- 1 cup rolled oats
- 1 cup chopped onions
- 1/2 cup peanuts (soaked)
- cumin, chili, and salt to taste

Combine all ingredients. Form into patties and fry.

**DEVELOPMENT CRITERIA FOR LC FOODS**

In testing different LC foods we are looking mainly for improvements in economics, acceptance, or nutrition. Although Leaf for Life is ultimately concerned with improving nutritional well being, in my opinion the priorities for testing are in the order given above. As we present the case for greater use of leaf concentrate to funders and policy makers,
the most serious doubts raised are generally concerning economics, followed by acceptance. The nutritional value of leaf concentrate is challenged less frequently. While most changes that affect any one of these factors will affect the other two, useful attributes for LC foods are sorted into these three categories below.

**Economics**

- **Long shelf life.**
  In many areas this means products that can be made during the rainy season and marketed six months later. A variation on this is making foods year round from dried LC.

- **Inexpensive, readily available ingredients.**
  Special attention to foods that tend to be inexpensive where malnutrition is prevalent, ie. cassava, yams, plantains, corn, sorghum, rice and potatoes.

- **Simplicity of process.**
  To be of much use in either fighting malnutrition or income generation for women LC foods must be fairly easy to make using inexpensive equipment that can be reasonably maintained in village conditions. Labor requirements should be well thought out, as should the need for technical expertise or precision.

- **Substitution for expensive foods.**
  It may be easier to market a cheaper substitute for a high demand food like meat or ice cream, than a premium priced enriched staple food like pasta or porridge.

- **Packaging.**
  Packaging can make up a big part of the cost of a food. Liquids and foods that are brittle or sticky, for example, can present costly problems.

**Acceptance**

- **Ready to Eat.**
  Foods that require no cooking are generally easier to introduce. Generally, people are more adventuresome about trying a snack food in the plaza than trying to integrate a new staple food into the traditional diet at home. Snack foods appeal more to the young, are identified with fun, and are usually sold in very small units, all of which encourages people to give them a try. Snacks represent the fastest growing part of the diet in many developing countries. They are usually not very nutritious, especially relative to their cost. Much of the snack market is controlled by companies from developed countries. So displacing a snack food with a new LC one would usually have a clear benefit both nutritionally and economically for the community. Development policies are beginning to question how introductions of foods might damage local production of staples.

- **Flavor.**
  Generally we view the flavor of LC as something that should be kept to minimum so that other more popular flavors can dominate even when foods contain significant amounts of LC.

- **Color.**
Normally the dark green of fresh LC is a liability as is the very dark, almost black, green of dried LC. Various schemes to lighten the color or alter it (such as with Pitahaya (hylocereus ocamponis), an intensely colored dark red fruit from a cactus like plant, in Nicaragua) are worth looking into.

**Nutrition**

- Contains Substantial Amount of LC. Many foods have been introduced through various projects that contained token amounts of LC. Probably 4 grams dry weight LC or 10 grams fresh per portion is a minimum if we are expecting much nutritional benefit. Malnourished children should get 25 grams fresh LC per day.
- Doesn't destroy or bind nutrients. Some processes, like exposure to prolonged high temperatures or sunlight can lower the nutritional value of the ingredients in foods.
- Makes nutrients more available. The addition of ascorbic acid makes it easier to utilize iron from LC. Some minerals are better absorbed in certain proportions to each other. Dried LC is more nutritious if it is ground extremely finely.

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**Course Outline**

**Suggestions for 5 Day Course for Leaf Concentrate Field Workers**

<table>
<thead>
<tr>
<th>Monday</th>
<th>AM:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes</td>
<td></td>
</tr>
<tr>
<td>&quot;Leaf For Life&quot; film</td>
<td>30</td>
</tr>
<tr>
<td>Orientation</td>
<td>45</td>
</tr>
<tr>
<td>Make LC with macerator</td>
<td></td>
</tr>
</tbody>
</table>

120
Make and taste atol (a thick warm drink) and porridge
PM
Agricultural aspects of LC
180
Questions and Answers

**Tuesday** AM
Make LC with blender and with grinder
150
Make tamales or basic Indian dishes
PM
Seminar on nutritional problems in developing countries and nutritional aspects of LC
120
Hygiene and safety
30

**Wednesday** AM
Make LC with macerator
150
Make drink syrup and discuss sugar preservation
PM
Byproducts (feeding ruminants, improving soil, biogas, ethanol and other possible uses
90
Economic aspects of LC and basic calculations
90
Questions and Answers

**Thursday** AM
Make LC with macerator
120
Dry LC
PM
Social and cultural aspects of LC programs
90
LC machinery
90
Questions and Answers

**Friday** AM
Reporting, Records Keeping, Accounting, and Communications
90
Make noodles and spaghetti
60
Frequently asked Questions, Frequently Encountered Problems
60
PM
EXAM
60
PARTY
??

**SAMPLE EXAMINATION**

1. What is the most common nutritional deficiency in the world?
2. Give 3 characteristics of plants that make good leaf concentrate.

3. Give 2 characteristics of plants that don't make good leaf concentrate.

4. What nutrient corrects night blindness?

5. Why is it important to bring leaf juice to the boiling point?

6. Name 2 things that can give leaf concentrate a bad flavor.

7. Why do women need more iron in their diets than men?

8. What is wrong with cutting leaves the evening before you process them?

9. Why is it better to heat leaf juice quickly than slowly?

10. What is the main advantage of a macerator or meat grinder over a blender for preparing leaf concentrate?

11. What other food processes can be done in a 5 gallon leaf blender?

12. Why do children not eat enough greens to provide significant amounts of protein in their diets?

13. If I process 50 kg of fresh alfalfa leaves, how much leaf concentrate should I make?

14. Which 2 of these animals make the most efficient use of the fiber left from leaf concentrate processing?
   Rabbit? Pig? Turkey? or Cow?

15. Why are leguminous crops like cowpeas and alfalfa good for the soil?

16. What is the biggest advantage of perennial crops over annual crops?

17. What is the youngest age that a child should begin getting leaf concentrate in his diet?

18. Which of these foods would help the body absorb iron the best?
   Tortilla? Milk? Guavas? or Beans?

19. Is it possible to get enough protein for excellent health without eating meat?

20. If I process 100 kg of fresh leaves with a moisture content of 80%, how much fiber should I end up with?
21. Why is calcium important to the human body?

22. What is the minimum length of time to wait before using leaves that have been sprayed with an insecticide?

23. Why is folic acid important?

24. What is the first thing to do when you come into the leaf concentrate workshop?

25. Why should leaf crops not be cut off at the ground

26. What is neem?

27. What can bio-gas be used for?

28. What is the main drawback with very small projects?

29. What are antioxidants, and why are they important?

30. Which of the following is most likely to improve the economics of an LC program
   a. lowering fuel use by installing a bio-gas generator
   b. saving electricity with a improved motor
   c. making the work day shorter
   d. increasing the % of LC yielded from the leaves.

OTHER LEAF CONCENTRATE PROCESSING EQUIPMENT & TECHNIQUES

LEAF PULPERS

THE BLENDER METHOD
The leaf concentrate blender is a fairly simple and inexpensive machine. It is similar to a household blender except that it has a 5 gallon or (20 liter) hexagonal container, a 1 ½-2 horsepower motor, and only one speed (3450 RPM).

Two to four liters of clean water (depending on the moisture content and toughness of the leaves) is poured into the blender, the top is fitted on, then the switch is turned on. The operator feeds the washed, cut leaves into the blender using a wooden push stick. How fast the leaves can be pushed into the blender depends on the type of leaf used and how wet or fibrous it is. The quantity of leaf that one can put into a single blender run is dependent on the same factors.

Usually about 3 kg (6.6 lb.) can be put into 3-4 liters of liquid in about two minutes. The blender should run about 20 seconds after the last leaves are put in to make sure all the leaves are ground up finely. If the leaves are especially dry or fibrous it pays to run the blender for a full minute after all the leaves are added and to use a little more liquid in processing. With a little experience it is possible to tell when to stop putting leaves into the blender by listening to the motor. As it works harder to chop the leaves it makes a lower pitched sound.

If the leaves are not coming out of the blender well pulped, you need to use more water or fewer leaves or allow them to be blended for a longer time. The leaves should be ground into an homogeneous slurry. If there is a lot of liquid it means that more leaves could have been blended in the water.

Next you empty the blender into a 5 gallon bucket then let it sit a few minutes. Experiments have shown that the yield of leaf concentrate increases if the ground leaves are allowed to remain in the water for up to ten minutes before being pressed. After ten minutes there is no further gain in yields. Then you pour the bucket slowly over the press table. There are several designs for press tables. There are drawings of press tables at the back of this manual.

The blender breaks the leaf cell walls well because the hexagonal shape of the container and the leaves circulating in a liquid medium bring the leaves into repeated contact with the high speed (3450 RPM) blades. If one added 2-4 liters of water to each batch of leaves blended the resulting leaf juice would be very diluted and a great deal of extra fuel and time would be needed to heat the juice to the boiling point. This problem can be avoided by blending the leaves in juice from earlier runs. So as soon as you have a gallon (4 liters) or so of juice pressed you can begin using it instead of water as the liquid medium for blending the leaves. Whey from earlier processing can also be used but we have had some problems with it, including very strongly flavored curd. Using water for each batch will result in a slightly greater recovery of curd than using leaf juice. This is because when the juice is pressed from the blended leaves a certain amount of moisture remains in the fiber. If the moisture remaining in the fiber is pure leaf juice rather than very diluted leaf juice, the fiber will contain slightly more protein at the expense of the leaf curd or LC. Except
when fuel costs are very low and leaf costs very high it is not normally economical to process the leaves only in water instead of leaf juice.

The 5 gallon leaf liquidizers are very useful for a variety of food processing tasks in addition to making leaf concentrate. They are well suited to making soymilk, which can in turn be made into tofu or soy bean curd. They are also good at preparing fruits drinks rapidly or in great quantity for group feeding situations. The liquidizers are very fast at breaking the pressed leaf curd into fine pieces for drying as well. There may be situations in which secondary uses such as these will influence the choice of leaf processing equipment.

The MEAT GRINDER Method

Hand operated meat grinders are inexpensive commercially available machines that do a good, if somewhat slow, job of pulping leaves for leaf concentrate preparation. Usually the meat grinders are marked with the numbers #32, #22, or #333. The #32 is the largest of the common meat grinders. The #333, the smallest, is too small for leaf concentrate processing except in the home. Any of these grinders can be powered by hand, by bicycle, or by electric motor. When they are motor driven the motor speed should be reduced to 60-80 RPM by gears or pulleys.

The mouth of the grinders should be extended at least 15 cm (6 inches) with a sheet metal guard to prevent hands from accidentally entering the grinder. A wooden or plastic push rod should always be used to push the leaves into the grinder. The push rod should have a head wide enough to prevent it from being pulled into the grinder.

The leaves should be cut or torn into pieces the length of a finger or shorter and fed slowly into the grinder to avoid it clogging. A custom made curved metal wrench that can offer some leverage is very handy for removing the retaining disc when the grinder gets clogged. The grinder powered by a motor with a speed reducer has enough torque to get very jammed up. Bits of juice and leaf are sometime shot more than a meter out of the grinder. For this reason, it is advisable to have a plastic skirt in front of the grinder to avoid getting green stains on everything.

When using a bicycle or an electric motor to power the grinder it is very important that the shaft of the grinder is precisely aligned with the power source. The speed of the motor (usually 1700 RPM) can be reduced with either gears or pulleys. The best method, but the most expensive is to use a sealed speed reducer, which has lubricated gears in a sealed steel casing. These cost between $150 - 250 US at the time of this writing. Sometimes you can buy the motor and speed reducer as an integrated unit, and this reduces the problem of alignment. However, the integrated units can be hard to work on and you may need to replace both components if one fails.
A series of pulleys can also be used to reduce the motor speed. It is less expensive but more difficult to use than the geared reducer. The pulleys must be firmly mounted and well aligned. The pulleys and the belts must be completely covered with some type of protective covering to keep hair or clothes from being caught.

You can adjust how finely the meat grinders pulp the leaves by putting in discs with different size holes. A disk with smaller holes will pulp the leaves more finely than a disc with larger holes. Unfortunately, the smaller holes also mean even slower grinding and they increase the problem of clogging. Remember to attach the grinder knife with the blades facing the disc. These knives can be sharpened periodically if necessary. After a bucket of leaves has been pulped, a liter or so of water should be added and well mixed in. The leaf pulp can then be treated the same as the pulp from the blender method.

The advantages of the meat grinders are that they are relatively inexpensive, and they can be found in a hardware store, rather than custom built. They can be used in remote regions without electricity and in homes. The meat grinders do a good job of pulping the leaves and use less water in processing than the blender method. This reduces the fuel necessary to heat the leaf juice. The meat grinders also adapt well to other food processes, like extruding churritos, mixing dough, and of course grinding meat.

The meat grinders also have some serious disadvantages. They grind leaves more slowly than blenders, hammermills or shredders. It is expensive and complicated reducing motor speeds from 1700 RPM to 60-80 RPM. Meat grinders work poorly or not at all with very high moisture crops like young alfalfa or mustard. Rather than being driven through the dieplate, very moist leaves are juiced in the grinder and the juice backs up and fills the grinder chamber. Meat grinders also present a danger of hands, hair, or clothes being pulled into either the grinder itself or the gears or pulleys. In addition, meat grinders are more difficult to clean than blenders.

HAMMERMILLS AND SHREDDERS

In several locations at several different scales of operation, hammermills and shredders have been used to pulp leaves for leaf concentrate. Both machines are essentially fast moving steel hammers or blades spinning on either a horizontal or vertical shaft. The leaf crop is fed into the chamber where the spinning hammers or blades hit it repeatedly until it drops out a shoot in the bottom or side of the chamber. Often the leaves need to be passed repeatedly through the chamber to rupture enough leaf cells for good leaf concentrate extraction.

The main advantages of the hammermills and shredders are that they can chop a lot of leaves very quickly and they don't require expensive speed reducers. There are many low cost commercially available machines that are designed to shred dry leaves to make mulch or to make animal feeds from forage or hay. Some of these can be modified to pulp fresh green leaves for leaf concentrate.
On the negative side, hammermills and shredders don't tend to break the leaves up enough to get good yields of leaf concentrate even with several passes. After the first pass it can be a sloppy operation passing wet pulp through the machines several times. Most hammermills are designed for grinding much drier materials and they can be nearly impossible to clean. Hammermills are used in a lot of industrial operations and are available in many sizes. Some of these machines are very noisy to be using indoors, and most of the leaf shredders have narrow exit holes that quickly clog with wet leaf pulp. It is important to remember, however, that development work, if on a somewhat limited budget, is continuing on these machines as well as all the other possible leaf concentrate making devices.

LEAF JUICE PRESSES

THE LEVER PRESS TABLE
A relatively simple and inexpensive table can be built without a jack to speed up the separation of the juice from the fiber. It is useful for small scale work. The table can be made from steel or sturdy wood, though the grate where the pressure is applied and the lever should be steel. The drawings that follow give a good idea how a press table can be built. It is possible to alter the plans somewhat to suit your particular needs, but a few important points should be kept in mind:

- The table should be at a height that is comfortable for the people that are using it.
- The lever needs to be at least 2.1 meters (7 feet) long and very stout. Smaller, lighter people need longer not shorter levers to exert the same pressure on the fiber.
- The steel bars or rods that make up the top of the lever press table need to be strong enough to resist the pressure applied by the lever. (see drawing in appendix).
- The table needs to be either bolted down or weighted to keep it from moving when pressure is applied. I prefer using sand bags for weight so the table can be moved for cleaning or reorganizing the workshop without the need for bolts in the floor.
- The workers must be able to move freely around the press table. The weight of the lever needs to be offset by a counterweight hanging from a rope on the other side of a pulley. This makes it much easier for the workers to lift the lever repeatedly. A sandbag counterweight can be adjusted to match the weight of the lever.
- The press table needs to be large enough to drain a 5 gallon bucket of pulped leaves. I suggest about 90 cm X 90 cm (3 feet X 3 feet).
- A frame made from 4 cm X 4 cm (1 1/2" X 1 1/2") wood with 6 mm (1/4 inch) metal screen firmly attached to the bottom should fit over the press table; and nylon filter cloth should be laid over this frame before the pulped leaves are poured onto the table.
- The juice needs to flow freely onto the sheet of metal or plastic under the press table, then into a bucket. The outlet of the metal or plastic sheet must be high enough to allow a bucket to be slid under for collecting the juice.
- The press table needs to be easy to clean. There should be no surfaces that will hold the juice and no surfaces that can't be reached for easy cleaning.

**Using the Press Table:**

A. Make sure that the wooden frame with hardware cloth or screen is in position and that filter cloth is laid over the frame.
B. Slowly pour a 5 gallon bucket of leaves that have been pulped in a blender or in a macerator or meat grinder onto the table. If the leaves were pulped in a meat grinder or macerator they need to be mixed well with an equal volume of water before being poured onto the press table.

C. Spread the pulped leaves out evenly over the table with a smooth spreading stick or with clean hands.

D. Grab all 4 corners of the filter cloth and twist them together to make a bag with all the pulped leaves inside.

E. Place the bag you've just formed under the lever press with the twist facing up. Gradually apply pressure by pressing down on the end of the lever. Maintain pressure for about 10 seconds.

F. Reposition the bag and repeat this step 3 or 4 times. The leaf pulp remaining in the cloth should now be too dry to easily squeeze liquid out with your hand.

G. The press table can also be used to press the 'whey' from the curd that has been strained into a cotton filter bag. Pressure needs to be applied more gradually and for a longer time than when pressing juice from pulped leaves. Avoid pressing curd that is still very hot as this tends to tear the filter bags.

H. Clean the press table well after each use.
THE Motorized Hydraulic PRESS TABLE

We also made and tested a variant on this press that employed an hydraulic piston powered by a 2 HP motor. The table is designed so that a motorized hydraulic piston and the manual hydraulic jack are interchangeable by removing 4 bolts. This press seemed faster and physically less demanding than the jack press. Alfalfa pressed with this press produced slightly more curd than that pressed with the jack in a very limited test. This system clearly needed modification before we could recommend its use. Mainly we need to exchange some of the system's speed for power. The pump may need to be adjusted to match the piston's capacity. A pressure relief valve could be installed to allow the system to hold its pressure at 8 or 10 tons for a few seconds before the return stroke.

The motorized hydraulic system costs about $600-700 US more than the jack press. When the relatively simple modifications are made it should be a fast, easy to operate, batch type press. It seems unlikely that a program processing 200 kg per day could justify the additional expense, but programs working with 500 kg or more daily might find it well worthwhile. It is a system that could probably be upscaled to at least double its output fairly easily by adding T's and a second piston. The easy interchangeability seems advantageous. This way a group could begin processing with a jack and switch to a motorized piston later if production warranted it. They would then have the jack as a backup if repairs or modification in the motorized system were ever needed. Hydraulic systems are known for being low maintenance once set up. The extensive use of hydraulics in tractor work means that rural areas frequently have some people with expertise in motorized hydraulic systems. Food grade hydraulic fluid can be purchased to minimize any possibility of contamination. Quick release couplings are very useful if the piston is going to be interchanged with a bottle jack.

Small Hydraulic Jack Plate PRESS

A simple and inexpensive version of the hydraulic jack press table can be built from steel. It has a 30 X 30 cm press plate and uses a 4 ton hydraulic jack. Rather than use springs to return the jack to its original position, the cross beam can be pushed down against the jack
after the pressure is released. Then the jack and the wooden press plate to which it is attached can be removed and the process repeated. It sits on a counter top rather than requiring a base. It is too small for general LC production but could be very useful in pilot programs, crop testing, and for doing demonstrations away from a workshop.

**HYDRAULIC Jack Cylinder PRESSES**

A number of relatively simple and inexpensive juice presses have been designed that use a hydraulic jack to apply pressure to leaf pulp in a perforated cylinder. Some of these utilize sturdy plastic PVC drain pipe of 15-30 cm (6-12) diameter with numerous small holes to allow the leaf juice to flow out when the pressure is applied. The pulp is held in a nylon bag that is placed inside the pipe to prevent the pulp from being driven through the holes. In another variation of this press, the chamber is metal with a fine metal screen fixed inside. Unlike the screw presses the hydraulic presses can also be used for separating the 'whey' from the curd. Some work has also been done with using hydraulic cylinders driven by an electric motor to accomplish the same thing more quickly. The motorized hydraulic presses appear to be too complex and expensive relative to how well they perform at removing leaf juice from pulp. A very similar juice press has been developed using a hand cranked arbor press rather than an hydraulic jack to apply pressure. It had very nearly the same advantages and drawbacks as the hydraulic units, though it did not apply as much pressure.

While the hand operated hydraulic presses are fairly simple and inexpensive, they are not without what we consider to be serious problems. They tend to be slow because they are batch rather than continuous presses. Our experience has been that if the disc that is driven into the cylinder is slightly too large or too small or misaligned, it is slow and frustrating getting it back out to reload the chamber with more pulp.

Hydraulic cylinder presses tend to apply a great deal of pressure on a fairly thick layer of leaf pulp, rather than gentler pressure over a larger area. One drawback of this is that as the leaf juice is driven out of the pulp nearest the cylinder holes, that pulp becomes dry enough to absorb the juice being driven out of the center of the cylinder.

A closely related problem is that the juice driven off with the initial light pressure is much richer in protein than the juice driven off towards the end with intense pressure. Some of the large protein molecules are filtered out of the juice when it is driven through a tight mat of drier fibrous leaf pulp at the edge of the cylinder. This problem can be greatly reduced by putting a disk of grooved wood or plastic with grooves cut into them to separate layers of leaf pulp an inch or so thick in the cylinder. Then the pressure is applied to several thin layers of leaf pulp stacked on top of each other. Unfortunately, this aggravates the first problem of slow reloading of leaf pulp.

**SCREW PRESSES**
Several presses for separating leaf juice from fiber have been tried. One of the most frequently used employs a cylindrical screw or worm that drives leaf pulp against a screen of some kind. The juice passes through the screen and is collected on a tray that sits below the screw cylinder. Some of the screw presses are set up so that the pulped leaves remain in contact with the screen until a certain pressure is built up by the screw. It then passes as fibrous residue out the end of the screw cylinder.

When they are carefully designed and tooled, screw presses are very good at separating the juice from the fiber in pulped leaves. They can be fed continually rather than in batches like the hydraulic and lever presses. On the other hand, they can be prone to clogging and can be very difficult to clean. Quite a bit of careful machine work needs to be done to make sure the clearances of the screw and the screen chamber are correct. Because of this skilled work and the cost of a motor and a speed reducer, the screw press can be a very expensive piece of machinery for a small project.

Hand operated screw presses are often used in wine presses and cider presses. In India we have combined a very heavy screw type truck jack with a table like the one described earlier (hydraulic jack press table). The advantages of hand driven screw presses is that they are extremely simple machines that are easy and cheap to maintain. One drawback of the hand operated screw is that it needs to be manually lifted off the pulp after each run. This can become slow and tiring. The hydraulic jack press avoids this problem by using springs to lift the press plate.

Testing is currently being done with a broad flat vertical axis screw press that could mount directly under the macerator. It turns slowly, about 4 RPM, but in theory could turn the macerator into a continual process operation.

**Combined Pulpers and Presses**

One line of development in leaf concentrate processing equipment basically combines a meat grinder with a screw press into a single machine. The leaves are fed into the grinder or pulper. After they are pulped they drop into a screw press chamber immediately below. The primary advantage of this machine is that a single person in a single continuous operation can remove the juice from leaf crops. Because it has only one motor and one speed reducer, it should be less expensive than the two component machines built separately.

These machines have been somewhat disappointing in use so far. It has been difficult to adjust the relative speed of the pulper and juicer section to compensate for differing moisture and fiber.
content of the leaves. Many small projects don't have an adequate supply of leaf crop to justify the cost and electrical capacity of these machines. They are heavy and quite difficult to clean or to do repair work on. However, they are being constantly modified and redesigned and they may still live up to their promise of becoming a relatively inexpensive machine that can process 100 kg of leaves an hour.

OTHER Leaf Pulpers AND JUICERS

There are several other machines that have been used experimentally or in small projects to make leaf concentrate. Work is being done on a modified shredder designed by Glyn Davys that moves the leaves down a spiral series of short hammers so that they have been hit many times before they exit the chamber. Another pulper that shows great promise is based on extrusion. Here the leaves are driven through holes in a die plate by a piston arm or through holes in an outer cylinder by a revolving eccentric cylinder within. It has been calculated that the extrusion method should be the most efficient technique for pulping leaves in terms of the energy required to pulp a given weight of leaves. Village scale extruders are not available, to the best of my knowledge. It has been estimated, by workers at the University of Wisconsin, that a processing rate of about one ton of fresh leaf crop per hour would be necessary before extruders would be the leaf pulpers of choice.

A manually operated extruder was built in England by modifying plans for a Bielenburg oil press. A small amount of leaf crop is pushed into a chamber and a long lever arm drives it through a narrow slot, rupturing the leaf cells. It appeared to be too slow and physically demanding to process on more than a household level, and probably too expensive to be reasonable for that scale of operations.

The range of devices that has been called upon to remove leaf juice from the pulp is quite extensive. Modified sugar cane rollers are used in a project in Pakistan. Small screw presses designed for village scale oil extraction have also been used. Commercial machinery designed for making fruit juices has similarly been put to this use. Electric washing machines have been slightly modified to spin the juice out of the pulp. The pulp is poured into a mesh bag inside the washing machine and run a couple of minutes on the spin cycle. Often washing machines discarded because their transmissions are broken can still run on the spin cycle, making for inexpensive centrifuges. These probably present difficulties in cleaning.

On a larger scale, a few different devices have been custom built for separating juice from leaf fiber. Continuous feed belt presses may be the most promising of these. These compress the pulp between a heavy food grade belt and a perforated rotating stainless steel cylinder. The leaf juice is driven into the cylinder through the perforations and runs out into a catch tank. The belt is held under tension between the perforated roller and another roller with heavy springs. Large scale leaf concentrate production is beyond the
scope of this manual, and people interested in large scale production should contact Leaf For Life's London office.

The wide variety of custom made machinery for leaf concentrate production is an indication of the resourcefulness, creativity and dedication of the hundreds of people who have worked on this food technology since the Second World War. This ingenuity is clearly a strength; but it also reveals a serious failing. For leaf concentrate production to become economic in thousands of towns and villages in the developing world, one or two standardized designs for low cost machinery will need to be selected. Only then will it be possible to manufacture on a limited scale, rather than custom build machines. Only then will the price of equipment drop off and parts become interchangeable. Until there is some degree of standardization of equipment it will be difficult and complicated training people to use a wide variety of machines, most of which they will never see.

LEAF CONCENTRATE DRYERS

Indirect Solar Dryers

There are several designs for solar assisted tray dryers. These use a solar collector to heat air that then rises through the chamber with the trays. The main appeal of these is that the heat source doesn't have an operating cost. Some of these type of dryers use fans to force the sun heated air over the drying trays. There are, of course, some drawbacks with solar energy as a heat source for drying LC. As mentioned earlier, leaf production tends to be best when the weather is rainy and cloudy. Even in the tropics solar energy is quite diffuse and in order to maintain relatively high temperatures (40-50°C [120 -140° F]) with an adequate airflow the solar collection area needs to be large. Glazing for large collector surfaces is difficult because glass is expensive, heavy and fragile, and polyethylene photodegrades rapidly (even more so as the ozone layer is depleted). Good insulation and sealants are not readily available in most developing countries and without them it is hard not to lose the heat collected before it flows thru the LC. The large areas involved in the solar drying of 10 -25 kgs of LC create handling problems and wind and rain protection become more expensive and complicated.

Electric Heated Tray Dryers

Similar trays were placed in a box heated with a 1500 W electric space heater and a small fan. These dryers worked fairly well with small quantities of LC, but the time and electric use were problems and the temperatures generated (c. 40° C [100 -110 ° F]) were too low for fast drying. This dryer had the advantage of being inside the workshop so it was independent of the weather. Heavy winds and rains are serious problems for large outdoor dryers. The trays need to be arranged in such a way that the heated air passes over each tray on its way out the vent at the top. We offset each tray 10 cm (4") so that the air had
to pass under each tray before rising to the next one. Even with offset trays, the LC closer to the source of heat will dry much faster than that furthest away in this type of dryer. It is advantageous to rotate the trays at least once during drying to move the trays furthest from the heating element in closer. This is an additional labor cost. If this rotating of trays can be done during normal working hours it is not much problem. However, often the drying will be going on in the evening after the workers have left the workshop, and having someone return to the workshop just to rotate the trays will be an irritating task.

One of the nice features of this type of dryer is that it can be hooked up to a timer and a thermostat, so that as you gain some experience in drying LC you can begin setting the thermostat for 50° C and the timer for however many hours you need for drying. The heater and fan can then be automatically turned off when the curd is dry even if that is in the middle of the night. This can reduce electric bills and prevent overdrying or burning of the curd. If the electric wiring in the workshop is not great or the timer, thermostat and heating element are not very well made, you may not want to be running this much electricity without someone around because of the possibility of a fire starting. The dryer we built in Nicaragua had 6 trays, each 80 X 80 cm (32 X 32”). I think it would have worked much better with a 3 kW heater. Of course, this would double the electricity usage and cost.

Many brands of electric food dryers can be purchased off the shelf in the US. Most of these are intended for household use and designed for drying a kilogram or two of fruit. Some can be expanded by adding trays. Unfortunately, because they don’t add to the heating element or air flow, this simply slows down the drying. These can be purchased for $50 -500 US depending on the size and quality. The better ones have built-in timers and thermostats. These are probably only an option for very small projects or people doing experimental work.

**Gas Dryers**

We also made a dryer that uses gas heat rather than solar energy. This provides a measure of security against moldy or inadequately dried curd on cloudy humid days. We built this dryer to fit over a gas cooker and to use drying trays that are interchangeable with the solar dryers. It is a box of light gauge galvanized sheetmetal, that captures heat from the cookers gas jets on the lowest setting. It has a capacity of about 8 kg (17.6 lb) fresh curd. After 2½ hours the LC was 6% moisture. It heated up to 70° - 80 C, which is higher than ideal for drying curd. It would probably do a better job quicker with a small exhaust fan attached to the top of the dryer. It may be possible to utilize the waste heat from heating leaf juice to power a dryer of this type, but it is difficult to keep steam from juice heating from rewetting the drying curd, unless they are separated by a wall of some kind.

**Tumble Dryers**

A heated tumble dryer with a fan was built in Nicaragua. It shows some promise but is a somewhat complicated gizmo with a geared motor to turn the drum, rollers, a heater, and a fan. Pete Fellows, with the Intermediate Technology Development Group, described using a drier like this with a 3 kW electric heater to dry about 3 kg of LC in a couple of
hours. If you can adjust the temperature of your dryer, for example with an thermostat controlled electric heater,

the LC can be dried more quickly by beginning with a higher temperature. Temperatures as high as 70° C [158° F] will not damage the nutritional value of the LC as long as it is moist. Once the curd becomes dry to the touch, the temperature must be kept below 50° C [140° F] or some of the amino acids may be damaged and the quality of the protein can be affected. In field applications it will usually be more practical to try to hold a steady temperature near 50°C. The saving in time would be quickly offset by overheating and ruining a couple of batches of LC. Generally, the simpler the technology the greater the likelihood of it actually functioning in developing countries.

CONTACTS

Leaf Concentrate Information:
LEAF FOR LIFE - USA
260 Radford Hollow Road
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tel-fax  606 986 5418

LEAF FOR LIFE - UK
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Fax 44171 261 9291

Leaf For Life - Bolivia
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Casilla 783
Oruro,
BOLIVIA

Leaf For Life - Sweden
Banergatan 85
11526 Stockholm
SWEDEN

Society for Green Vegetation Research
Central Food Technology Research Institute
Mysore 570 013  (publishes newsletter)
INDIA

Other Organizations Involved in Leaf Concentrate Projects:
Pastoral Social- Caritas
1 de Mayo # 335
Morelia, Michoacan CP 58000 MEXICO
telefono: 52 43 12 98 90 fax: 52 43 12 10 00 52 43 12 70 40

SOYNICA
Aptdo RP-05
Managua NICARAGUA
FAX - 011 505 2 89 49 41

Leaf Nutrient Program, Inc. (project in Coahuila, Mexico)
1203 N. Expressway 77
Box 334
Harlingen, Texas 78552
USA

Groups Doing Related Health and Nutrition Work:

Hesperian Foundation (Publishes "Where There is No Doctor" and other excellent books for health care workers in developing countries)
1203 N. Expressway 77
Palo Alto, CA 94302
USA

Clearinghouse on Infant Feeding and Maternal Nutrition (Publishes newsletter)
American Public Health Assn.
1015 15th Street NW
Washington, DC 20005
USA

International Vitamin A Consultative Group & International Nutritional Anemia Consultative Group
Nutrition Foundation
1126 16th Street NW
Washington, DC
USA

Johns Hopkins Hospital (Research on Vitamin A Deficiency)
120 Wilmer Eye Institute
600 N. Wolfe Street
Baltimore, MD 21205
USA
Helen Keller International (Fights Nutritional Blindness)
15 W. 16th Street
New York, NY 10011
USA

La Leche League International (Promotes Breast Feeding)
PO Box # 1209
Franklin Park, IL 60131-8209
USA

Related Agricultural Information:

ECHO (publishes excellent newsletter offers small packets of seed)
17430 Durrance Rd.
North Fort Myers, Fl 33917
USA
fax 941 543 5317

Bean/Cowpea CRSP (Publishes Newsletter)
200 Center for International Programs
Michigan State University
East Lansing, MI 48824-1035
USA

Liphatech (Sells Legume Inoculants)
3101 W. Custer Ave.
Milwaukee, WI 53209
USA

International Agriculture Sieve (Publishes Newsletter)
Rodale Institute
222 Main Street
Emmaus, PA 18098
USA

TRIADIES
Pacific Neem Project
Box E
Hakalau, HI 96710
USA
Asian Vegetable Research and Development Center
PO Box # 42
Shanhua, Tainan
Taiwan, Republic of China 74199

Food Processing Equipment:

Unichop
140 E. Commercial Dr.
Wooddale, IL 60129
USA
Grace Valenti
PO Box 105
54-36 Flushing Ave.
Maspeth, NY 11378
USA

Lehman Hardware
PO Box #41
4779 Kidron Road
Kidron, OH 44636
USA

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Dept. of Agricultural Engineering
460 Henry Mall
University of Wisconsin
Madison, WI 53706
USA

INTSOY
Dept. of Food Sciences
University of Illinois,
Urbana-Champaign
1304 W. Pennsylvania Ave.
Urbana, IL 61801
USA

note: Many of these organizations are non-profit groups with very limited budgets. When asking for information, please enclose a self addressed stamped envelope.
BOOKS

Leaf Concentrate

Pirie N.W. Leaf Protein and Its By-products in Human and Animal Nutrition Cambridge University Presss Cambridge, UK 2nd Ed. 1987 209 pages

Agriculture and Environment


Sarrantonio, Marianne. Methodologies for Screening Soil Improving Legumes. Rodale Institute 611 Siegfriedale Road Kutztown, PA 19530 USA. 1991 310 pages

Price, Martin  ECHO Development Notes ed. 17430 Durrance Rd. North Fort Myers, FL 33917-2200 USA Subscription $10 US per year


Better Pastures for the Tropics  Yates Seeds P.O. Box 616 Toowoomba, Qld., 4350 Australia 1975  60 pages


**Processing**


Fellows, Peter and Axtell, Barry  *Appropriate Food Packaging*  published by Transfer of Technology for Development  Amsterdam  135 pages

**Nutrition**

Cameron, Margaret and Yngve Hofvander  *Manual on Feeding Infants and Young Children*  Third Edition Oxford University Press, Toronto, Ontario Canada 1983  214 pages


*Nutrition Screening Manual For Professionals Caring For Older Americans* Nutrition Screening Initiative Washington, DC 1991


**Management, Marketing, Training, Communications**


de Wilde, Ton; Schreurs, Stigntje; and Richman, Arleen. *Opening the Marketplace to Small Enterprise* Intermediate Technology Publications London 1991 155 pages


MAKING LEAF CONCENTRATE AT HOME

1. **Wash and cut leaves.** Use only fresh green leaves known to be edible, such as alfalfa, Swiss chard, lambsquarters, blackeye peas, wheat, mustard, kale, or collards. While many other plants make good concentrate, it is safer for beginners to stick with commonly eaten leaf crops. Wash in cool water to remove dust and dirt and cut into pieces 2 - 3” long.

2. **Grind the leaves to a pulp.** This can be done with a manual meat grinder or flour grinder, a wheat grass juicer, or a household blender. Fruit and vegetable juicers usually clog up quickly from the large amount of fiber in leaves. I prefer using a blender on the highest speed 1/3 full of water. This step ruptures the cell walls of the leaves liberating protein and other nutrients.
3. **Press as much juice as possible from the pulped leaves.** Pour the pulped leaves into a sheer nylon or polyester cloth of the type used for curtains. Squeeze out as much juice as possible. You should not be able to squeeze any juice out of a handful of this pulp when you are done.

4. **Heat the juice rapidly to the boiling point.** Stir very gently to prevent burning and remove from heat as soon as the leaf juice boils. A green curd should float to the top.

5. **Separate the curd that forms in the heated juice in a closely woven cloth.** When this wet curd has cooled squeeze the "whey" out of the curd. It should be dry enough to crumble. You may want to make a very simple press with a 2" X 4" X 8' lever to apply more pressure than you can with just your hands. This can be used for pressing the juice from the pulped leaves as well.

6. **What remains in the cloth is LEAF CONCENTRATE!**
   - 10 lbs of leaves should give you roughly ½ lb leaf concentrate; 4½ lbs of fiber for mulch, compost, rabbits or goats; and 5 lbs of "whey" for watering plants. Leaf concentrate can be dried at about 120° F, ground to a fine powder and stored for later use in airtight plastic bags away from any light. **Good Luck!**
### Macerator Components

<table>
<thead>
<tr>
<th>PIECE</th>
<th>WHERE MADE</th>
<th>ESTIMATED COST</th>
<th>ESTIMATED WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Feed Hopper</td>
<td>Local</td>
<td>$ 30 US</td>
<td>6 kg</td>
</tr>
<tr>
<td>2. PVC Cylinder</td>
<td>Local or Import</td>
<td>$ 30</td>
<td>10 kg</td>
</tr>
<tr>
<td>3. Frame</td>
<td>Local</td>
<td>$ 125</td>
<td>20 kg</td>
</tr>
<tr>
<td>4. Motor (2HP 3600 RPM) &amp; switch</td>
<td>Local or Import</td>
<td>$ 220</td>
<td>24 kg</td>
</tr>
<tr>
<td>5. Shaft, bearings, hub, blade and</td>
<td>Import</td>
<td>$ 300</td>
<td>10 kg</td>
</tr>
</tbody>
</table>
### Assembly of Macerator

1. You can purchase piece #5, the shaft, bearings, hub, blade and mounting assembly from Leaf For Life for $300 US plus shipping. This includes a heavy stainless steel shaft, two bearings, (the top one being nickel plated food grade), a mounted pulley and 12.5 mm (½”) high density nylon blades covered with 16 gauge stainless steel. These are set in a steel bearing support that can be welded to a locally built frame. This assembly also includes an aluminum cover to protect the drive belt. This is the only piece that is difficult to build locally in many locations.

2. If you decide to purchase this assembly follow the steps below:
   - **a.** Disassemble the bearings and aluminum cover, noting how they fit back together.
   - **b.** After welding the bearing support to the built frame, reassemble the aluminum cover and bearings. Any lips or edges of the aluminum cover should face down to collect the least amount of pulp.
c. Before mounting the cylinder and cylinder supports, assemble the blade and mount it on the shaft. This will allow for the correct positioning of the cylinder. There should be about 6.25 mm (1/4") between the tip of each blade and the inside cylinder wall.

3. For safety make sure the drive belt is covered both under and outside of the cylinder.

4. The outside diameter of the blade shaft pulley is 70 mm (2.8 "). The pulley on the motor should be the same size or as close as possible. If the pulley on the motor has a much larger diameter it will cause unacceptable vibration.

5. The motor should be a good quality two horsepower 3450 RPM electric motor. Most motors this size can be set to run on either 110 Volt or 220 Volt current. Make sure that the motor is set for the wall current that you are using. If you have the choice use 220 Volts as the motor will run cooler and last longer. Also be sure that your motor is built for the frequency of electricity that you will be using. Most of the world uses 50 Hz frequency, but the United States, Mexico and parts of Latin America use 60 Hz. A 60 Hz motor running on 50 Hz electricity will run about 17% slower and will overheat easily.

6. A plastic washtub as large as will easily slide under the pulley and belt should be used. For a smooth operation you'll probably want two or three of these, so they can be switched quickly without stopping the leaf pulping.

7. You may want to attach flexible plastic flaps to the frame to prevent bit of pulp from flying out over the top of the washtub. This is especially important if you plan to use the macerator to granulate leaf curd as well as pulp leaves.

8. To reduce noise, vibration, and movement of the macerator, rubber feet of some type should be fitted to the legs of the frame. The frame should also be secured to the floor or a wall in some manner.
Development policies are beginning to question how introductions of foods might damage local production of staples.

- Flavor.
Generally we view the flavor of LC as something that should be kept to minimum so that other more popular flavors can dominate even when foods contain significant amounts of LC.

- Color.
Normally the dark green of fresh LC is a liability as is the very dark, almost black, green of dried LC. Various schemes to lighten the color or alter it (such as with Pitahaya (Hylocereus ocamponis), an intensely colored dark red fruit from a cactus like plant, in Nicaragua) are worth looking into.

**Nutrition**

- Contains Substantial Amount of LC.
Many foods have been introduced through various projects that contained token amounts of LC. Probably 4 grams dry weight LC or 10 grams fresh per portion is a minimum if we are expecting much nutritional benefit. Malnourished children should get 25 grams fresh LC per day.

- Doesn't destroy or bind nutrients.
Some processes, like exposure to prolonged high temperatures or sunlight can lower the nutritional value of the ingredients in foods.

- Makes nutrients more available.
The addition of ascorbic acid makes it easier to utilize iron from LC. Some minerals are better absorbed in certain proportions to each other. Dried LC is more nutritious if it is ground extremely finely.

Sarrantonio, Marianne. *Methodologies for Screening Soil Improving Legumes.* Rodale Institute 611 Siegfriedale Road Kutztown, PA 19530 USA 1991 310 pages

Price, Martin. *ECHO Development Notes* ed. 17430 Durrance Rd. North Fort Myers, FL 33917-2200 USA Subscription $10 US per year


Better Pastures for the Tropics. Yates Seeds P.O. Box 616 Toowoomba, Qld., 4350 Australia 1975 60 pages


Information Centre for Low-External-Input and Sustainable Agriculture in the Netherlands
Farming for the Future: An Introduction to Low-External-Input and Sustainable
Agriculture Macmillan Press Houndmills, Basingstoke, Hampshire RG21 2XS UK

U.S. National Research Council Saline Agriculture: Salt-Tolerant Plants for Developing
Countries National Academy Press Washington, DC USA 1990 143 pages

Processing
Mazur, Glen A. and Thomas E. Proctor. Troubleshooting Electric Motors. American
Technical Publishers, Inc., Homewood, IL 60430 USA 1993 299 pages

Fellows, Peter and Hampton, Ann Small-Scale Food Processing: A Guide to Appropriate

Fellows, Peter and Axtell, Barry Appropriate Food Packaging published by Transfer of
Technology for Development Amsterdam 135 pages

Nutrition
Cameron, Margaret and Yngve Hofvander Manual on Feeding Infants and Young
pages

King, Maurice and Felicity King. Primary Child Care: A Manual for Health Care
Workers Book One and Two, Oxford Medical Publications, Toronto, Ontario Canada 0X2 6DP
1991 311 pages and 194 pages.

Natow, Annette B. and Jo-Ann Heslin. Nutritional Care of the Older Adult MacMillan
Press NY 1986 306 pp

A Resource Guide for Nutrition Management Programs for Older Persons US Dept. of
Health and Human Services (Administration on Aging) 1985

1185 Avenue of The Americas NY, NY 10036 1991

Management, Marketing, Training, Communications

Werner, David and Bill Bower Helping Health Workers Learn The Hesperian
Foundation, Palo Alto, Ca. 1982

Boyden, Jo and Brian Pratt The Field Directors’ Handbook: An Oxfam Manual for
Development Workers Oxford University Press Toronto, Ontario Canada 1985 512
pages

de Wilde, Ton; Schreurs, Stigntje; and Richman, Arleen *Opening the Marketplace to Small Enterprise* Intermediate Technology Publications London 1991 155 pages

Kindervatter, Suzanne with Range, Maggie *Marketing Strategy: Training Activities for Entrepreneurs* Overseas Education Fund New York 93 pages

Rittner, Don *Ecolinking: Everyone's Guide to Online Environmental Information* Peachpit Press Berkely, CA USA 351 pages

**IMPACT MACERATOR**
(measurements in inches; 1 inch = 25.4 mm)

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