



Sweet potato (*Ipomoea batatas*)



Moringa (*Moringa oleifera*)

Selecting Leaf Vegetable Crops for Growing

There is no doubt that leaf vegetables could play a bigger role in improving human nutrition and health. Much less well known are the potential ecological benefits of growing more leaf crops. Growing more plant species and varieties, and being able to derive value from more than one part of most plants requires the grower to have a greater understanding of botanical patterns. The mechanization of tasks becomes difficult with more integrated systems, thus labor costs are higher. The higher labor costs may be offset by the greater flexibility and greater resilience of a more complex agriculture.

Remember that any one leaf crop, regardless of how it is prepared, has some potential for ill effects if eaten in large enough quantities. The inverse of this is also true. No single crop can provide the range of positive nutritional attributes that a mix of different leaf crops offers. What is true of nutrition is equally valid in sustainable agriculture. A plant that is renowned for its lack of insect pests will not stay that way if it is repeatedly planted in large monocultures. There are many wonderful leaf crops, but none so great as to warrant the exclusion of the others.

Eighty plants are listed below to aid in deciding what to plant. Every one of these plants can provide significant nutritional benefit. They are grouped according to the potential ecological benefits that they can offer the grower.

POPULAR TEMPERATE ZONE LEAF VEGETABLES

Perhaps the most commonly eaten leaf vegetables in the world are lettuce, spinach, and varieties of cabbage. The dominance of these three can be seen in the names of less popular greens. Samba lettuce, New Zealand and Malabar spinach, skunk cabbage and sea cabbage are names derived from the popularity of the big three. It is easy to find information about growing and cooking with these popular vegetables, so they are just touched on lightly here.

Lettuce - *Lactuca sativa*

Lettuce is the most popular leaf vegetable in the world. Native to the area around what is now Turkey; it has been grown in Egypt for nearly 7,000 years. Cultivation of lettuce spread with the Greek and Roman Empires and was carried into the tropics with the European colonial expansion. It is an annual or sometimes a biennial¹ in the aster (sunflower) family and is generally classified as either head lettuce or leaf lettuce.

¹ Biennials are plants that usually take two years to complete their lifecycle. In the first year the plant grows leaves, stems, and roots, and then goes dormant until the next year when it produce seeds. There are far fewer biennials than either annuals or perennials. Many of them, including carrots, beets, and cabbage, are actually grown as if they were annuals because we are mainly interested in their edible leaves, roots, and stems formed in the

Lettuce prefers light, well drained, slightly acidic soil with plenty of organic matter. Some varieties are very cold hardy and most do best with cool weather and full sun. Lettuce quickly becomes bitter and bolts in high temperatures, but this can be delayed considerably by providing partial shade. Unlike most vegetables, lettuce seed will germinate in the sunlight and so is often planted on the surface and pressed into the soil to ensure good contact.

Leaf type lettuces can be sown densely and harvested repeatedly as the plants become crowded. Head type lettuce requires wider spacing to allow for good head formation. Lettuce seedlings get off to a strong start when they are started in float beds and then transplanted to the garden. Float beds are Styrofoam planting trays that are floated in shallow water so the young lettuce plants can wick up water and never get too dry. A variety called Queensland lettuce is adapted to the hotter tropical regions, though its flavor and texture are not as delicate as the temperate zone lettuces.

While the whole plant is always harvested with head type lettuce, leaf lettuce can be harvested by cutting or pinching the outer leaves or by cutting the whole plant at about 2.5 cm (1 in) above the ground. Given adequate soil moisture the leaf lettuce will regrow for at least a second

first year, rather than the flower and seed of year two.

harvest. Because lettuce grows quickly and then becomes bitter, it is well suited to planting every 10–14 days. This succession planting schedule will provide a continual supply of high quality lettuce until the weather gets too warm.

Lettuce is usually eaten raw, although in China the stems are often cooked. It is not a nutritional giant, but can supply a modest amount of vitamins, potassium, and antioxidants. Leaf lettuce is much richer in nutrients than head lettuce, and red lettuces have stronger antioxidant properties than green varieties. Because it is eaten raw, it is especially important to avoid contamination of the soil from fresh animal manure and to wash the lettuce well before eating it.

Spinach - *Spinacia oleracea*

A member of the Chenopodium family, spinach originated in the region that is now Iran and Iraq. It has been cultivated for at least 2,000 years and is now grown throughout the world's temperate zones and cooler tropical regions. It is an annual plant grown exclusively for its tender leaves that can be eaten either raw or cooked.

Spinach grows well on soil with good drainage and organic matter, as long as it is not very acidic. Spinach is grown in the cooler weather of both spring and fall. Bolting is brought on by lengthening days and warm weather, so spinach tends to remain tender for a longer time if planted in fall rather than spring. Nitrate fertilizers should be avoided, especially in

winter-grown spinach, as they can cause excessive accumulation of nitrates in the leaves. Because nitrates are concentrated in the stems, they should be removed if feasible.

Like leaf lettuce, spinach can be harvested by plucking off the outer leaves or by cutting the whole plant off at 2.5 cm (1 in) above the ground. It will usually produce a second and possibly even a third harvest if soil has plenty of organic matter and moisture. Succession planting every 2 weeks will provide for a long season of fresh spinach.

Spinach is a mild flavored green that has been used in thousands of recipes. It is an excellent source of vitamin A, folate, lutein, and potassium. Although it contains high levels of iron and calcium, spinach is not a good dietary source of these minerals, because the oxalic acid in spinach leaves interferes with the absorption of these minerals.

Mustard/Cabbage Family - *Brassica spp.*

There are two important clans in the mustard family leaf vegetables: one originating in the Mediterranean and one in China. Both varieties have spread throughout most of the world except for the hotter tropical areas. Although they take numerous forms, these plants are quite similar in their agricultural requirements, nutrition, and usage.

All of the brassicas are heavy feeders that prefer growing in rich organic soil with

a nearly neutral pH. Full sunlight, cool weather and moderate soil moisture are ideal. They are all grown as annuals and all propagated by small round seeds. Brassica plants grown for leaves rather than heads are almost always direct seeded, whereas head cabbage, broccoli, and cauliflower are often started as sets and later transplanted into the garden. Temperatures above 25° C (77° F) slow the growth of brassicas.

Very young brassicas are often attacked by flea beetles, while older ones are subject to feeding by cabbage worms, cabbage loopers and diamondback moths. Bt (*Bacillus thuringiensis*) based organic insecticides are very effective on cabbage worms.

China, Korea, and Japan lead the world in the production of both Asian and European types of brassicas. They are sometimes eaten raw when young, but more often lightly steamed or stir-fried. Brassicas are among the most nutritious of all foods. They are rich in vitamin A, vitamin C, vitamin K, calcium, iron, and protein. The minerals are generally well-absorbed because brassicas contain little oxalic acid. They are extraordinary sources of cancer-fighting antioxidants, especially isocyanate and lutein.

European Cabbages

Cabbage –*Brassica oleracea* var. *capitata*

Kale –*Brassica oleracea* var. *acephala*

Collards –*Brassica oleracea* var. *acephala*

Mustard Greens –*Brassica juncea*

Turnip Greens –*Brassica rapa* var. *rapa*

Asian Cabbages

Pak choy –*Brassica rapa* var. *chinensis*

Pe-tsai –*Brassica rapa* var. *pekinensis*

Mizuna –*Brassica rapa* var. *japonica*

Mibuna –*Brassica rapa* var. *japonica*

Komatsuna –*Brassica rapa* var. *perviridis*

Multi-use Leaf Crops

The ability to obtain each of the nutrients we need from a wide variety of food sources has been an enormous evolutionary advantage for omnivorous humans. Like a social insurance program, enlarging the biodiversity of our agricultural systems confers the benefit of distributing the risk. In highly specialized farming systems the production of specific commodities may be higher while the labor costs are almost always lower. However, more ecologically complex food growing systems will typically have higher total output and better protection against catastrophic crop failures.

The same diversity principle can be applied to individual plants. Most plants that we grow for food have more than one potential use. While commercial agriculture normally focuses on the single most profitable output from a plant, a sustainable system can make use of the whole plant. For example, we can eat both the sweet potato and its leaves. Having two nutritious products from a single plant offers the grower an important advantage in food security. This fact has not been lost on NASA, which is investigating both quinoa and cowpeas, two seed crops with edible

leaves, as possible crops in their Controlled Ecological Life Support System for manned space flights of long duration.

Virtually all crops are initially leaf crops, and often finding additional uses for food plants simply means finding a way to make better use of their leaves. . The key is to see the plants in their entirety, not just as a source of a particular food product. This perspective offers the creative gardener a much wider range of botanical options for supper. Techniques, such as solar drying and making leaf concentrate, that enable us to more effectively capture, preserve, and absorb the nutrients in green leaves, greatly improve the prospects for these multiple-use food plants.

This section describes how to grow some of the plants that have edible leaves in addition to other uses and why they might be worth growing. The first and probably most important category of multi-use leaf crops, edible cover crops, was discussed in chapter 12. Other important categories of multi-use leaf crops include staple food crops with edible leaves and traditional garden vegetables with edible leaves.

Staple Food Crops with Edible Leaves

The diet of most of the world's people is heavily dependent on the availability of cheap carbohydrates from staple grain and root crops. Among the grains, wheat and barley are useful sources of edible green leaves. The world's most important staple root crops are potatoes, cassava, sweet

potatoes, yam, taro, and tannier. Cassava, sweet potatoes, taro, and tannier plants can all supply edible green leaves, though some precautions need to be taken with cassava, taro, and tannier leaves.²

Regionally important dietary staples also include several pseudo-grains or pseudo-cereals. These are broad leaf plants, rather than grasses, that produce large yields of edible seeds that are used like grains (seeds of annual grasses). The most important of these are amaranth, buckwheat, and quinoa. Amaranth and quinoa both produce edible leaves with long histories of usage in regional diets. In addition to three grain amaranths (*Amaranthus hypochondriacus*, *A. cruentus* and *A. caudatus*) and quinoa (*Chenopodium quinoa*) there are several closely related members of the amaranth and chenopodium families that have been used on a more limited scale for

² Although they are eaten in some cultures, potato leaves, stems, and green portions of potatoes contain solanine and chaconine, two related glycoalkaloid toxins, and should be consumed in very small quantities if at all. Tomatoes and eggplants, two other members of the potato family, also have somewhat toxic leaves. Even the green tomato fruit contains enough solanine to be dangerous if consumed raw in large quantities. Noted food expert Harold McGee argues that the case against eating tomato leaves is weak, and that small amounts could be used as flavorings.

New York Times, Dining & Wine Section, Accused, Yes, but Probably Not a Killer, By Harold McGee, July 28, 2009

both their grain-like seed and their edible leaves.³

Sweet Potato - *Ipomoea batatas*

Sweet potatoes are sprawling perennial plants that probably originated in Central America, where they have been cultivated for over 5,000 year. The crop is now grown throughout the tropics and the warmer parts of the temperate zone. Sweet potatoes are among the ten most important food crops in the world, though much of the crop is grown by subsistence farmers for home use.

Sweet potato is an ideal crop for fighting malnutrition. It is well suited to survive and to produce crops on infertile tropical soils, even without fertilizer, irrigation, machinery, or improved genetics. It is an excellent dual-purpose food crop because its leaves are nutritious and widely eaten. Both tuber and leaves are rich in pro-vitamin A, folate, and calcium. The leaves are perhaps the best source of the antioxidant lutein, which is important in protecting our skin from sun damage and our eyes from age-related loss of vision.

Though often grown as an annual, sweet potato is a perennial vine that can produce edible tubers and leaves for up

³ Although they contain the toxin fagopyrin, buckwheat leaves or sprouts have recently become part of certain raw foods health regimens. In very small amounts they probably are harmless; however, drinking juice from buckwheat greens can cause the skin to become extremely sensitive to sunlight.

to six years without replanting in tropical climates. In a system where both the leaves and tubers are well managed for good yield, sweet potatoes can probably produce more nutrients per acre than any other crop, including more calories per acre than cassava. They have one of the highest returns of nutrients-relative to the time and effort expended-of any crop.

Sweet potato grows best in loose sandy soil, but will thrive in any well drained soil. It is a very frost sensitive plant that requires at least 100 warm days to produce tubers of reasonable size. In cooler climates black plastic is sometimes used to warm the soil, and floating row covers can help warm the air around the plants. Even where the growing season is too short to get good yields of tubers, sweet potatoes can be grown for their leaves. High levels of nitrogen will favor foliage growth at the expense of tuber size. A slightly acid soil pH is ideal.

Sweet potato plants are usually grown from slips in the temperate zones and from stem cuttings in the tropics. Slips are grown from untreated sweet potatoes by placing them in a few inches of sand or suspending the sweet potato in water about six weeks before the last frost. They need to be kept warm during this time. In the tropics they are usually started to coincide with the beginning of the rainy season and can be grown as short lived perennials.

When shoots are 15–23 cm (6–9 in) high they can be gently twisted and pulled from the mother sweet potato and planted in the garden. Slips are usually planted 30–46 cm (12–18 in) apart. Closer spacing results in more sweet potatoes but smaller size, while wider spacing produces a smaller number of larger tubers. Sweet potatoes can also be grown closely spaced to smother weeds. When planted 15 cm (6 in) apart or closer, they will quickly form a dense groundcover that is both attractive and edible. This is a realistic way of removing tough perennial grasses or nutsedge from a garden or field without resorting to herbicides. Sweet potatoes are also one of the best edible greens to grow in containers or hanging baskets.

Once they are well-established, up to 50% of the leaves can be harvested every three weeks. Lighter or less frequent leaf harvests will result in greater tuber yield, but the maximum total food value will always come from combination of leaf and tuber harvesting. The stems of sweet potato are often eaten along with the leaves, but they offer little beyond water and fiber. Given good conditions for growth, up to 55 metric tons per hectare of fresh sweet potato greens (25 tons/acre) could be harvested.

Although it is already one of the world's leading food crops, sweet potatoes have enormous potential that remains to be tapped. Flexible systems that optimize

combined leaf and tuber yield need to be developed to realize that potential. Breeding for varieties that are high yielding, pest resistant and starchy tasting, like Irish potato rather than sweet, could put sweet potatoes at the center of the effort to feed the huge populations of the tropics in the near future. Their ability to produce good yields with minimal fertilizer will become more crucial as energy prices inevitably escalate.

Cassava - *Manihot esculenta*

Cassava is native to the Amazon region of South America. It is a perennial shrub that grows up to 4 m (13 ft) tall. One of the world's ten most important foods, it is grown primarily for its starchy roots, which are a staple for nearly one billion people. Cassava is closely associated with extreme poverty because it is grown and eaten mainly by people with few economic resources in Africa, Asia, and Latin America.

It will survive long droughts by shedding its leaves and going dormant until rains return. It is also a plant capable of growing in soil that is very acidic, low in nutrients and high in toxic aluminum compounds. These growing conditions are increasingly common in the degraded agricultural ecosystems of the tropics. Its ability to produce food under such harsh conditions makes cassava “the poor man's friend.” It is intolerant of frost, and good temperate zone varieties are not yet

available. It prefers slightly acid soil but doesn't tolerate high salinity.

Cassava is typically grown from stem cutting roughly 50 cm (20”) long. These are pushed about 20 cm (8”) deep into the soft ground after a good rain. Cuttings are usually spaced about 1 meter (40”) apart in each direction. Where cassava leaves are eaten as well as the roots, stem cuttings can be planted closer together. Closer spacing and high levels of available nitrogen in the soil favor rampant leaf growth over edible roots.

The value of both the leaves and the roots is limited by the presence of two glucosides: linamarin and lotaustralin, compounds that can produce hydrocyanic acid (HCN) when cassava is eaten without proper processing. HCN is a common plant toxin that occurs naturally in lima beans, sorghum, and many other crops. It is discussed in Chapter 6. HCN from cassava rarely causes acute poisoning. However, in areas where cassava is an important source of calories, long term or chronic HCN toxicity can lead to irreversible nerve damage and other serious health problems. Chronic HCN toxicity is most common among people with marginal quantities of protein in their diet, people with low levels of dietary iodine, and among smokers.

Processing cassava leaves properly is essential. The leaves contain 5 to 20 times more linamarin than the roots. Fortunately they also have perhaps 200 times more

of the enzyme linamarase, which breaks down the linamarin and releases the HCN. By pounding or shredding the leaves finely, the linamarase can release most of the HCN into the air before the leaves are cooked. The pounding or fine shredding of the leaves should be done outdoors or with adequate ventilation. The pounded cassava leaves should be boiled for at least 15 minutes, and many cultures boil them for twice that long. There is significant loss of nutrients, especially vitamin C and folate with this method, but the benefit of removing the HCN more than offsets these losses.

If the cassava leaves are being dried for later use, they should be pounded or finely shredded before drying. High temperatures neutralize the linamarase so, unlike most leaf crops, it is better to not blanch cassava leaves before pounding, grinding, or shredding them. Much of the HCN that is not released by pounding or shredding the leaves will dissipate into the air while they are drying. As an added precaution it is best to use the dried cassava leaves in dishes that will go through further cooking, such as pasta.

Cassava exhibits a wide range of toxin levels, so regional research and extension agencies throughout the tropics could screen varieties for HCN content in their leaves, encouraging people to grow safer varieties. High HCN levels in cassava leaves provide the plant protection against insect

attack, but varieties could be developed that more optimally balance the demands of insect protection and food safety.

Almost everywhere that cassava is the chief staple food, there are deficiencies of protein, iron, and vitamin A. Ironically, just combining the properly processed leaves of the cassava with the starchy root of the same plant could go a long way towards resolving the world's worst malnutrition.

Harvesting a few leaves every day from a small household planting of cassava can provide a great deal of nutritional insurance without significantly lowering the yield of the starchy roots. Annual yields as high as 176 metric tons per hectare (80 tons/acre) of fresh cassava leaf have been reported from three cuttings. However, this sort of heavy leaf yield greatly lowers the production of storage roots. Repeated partial leaf harvests totaling up to 24 metric tons per hectare (11 tons/acre) of fresh cassava leaf can sometimes be obtained without significantly depressing the yield of roots. Careful harvesting of the top leaves may actually increase root yield by encouraging the growth of side shoots. Partial leaf harvest should be delayed until the plant is at least six months old, for the best yields of leaf and the least loss of tuber yield.

As with sweet potato, a flexible system for growing and using both the roots and leaves of cassava has enormous potential for addressing malnutrition and food security issues. Getting multiple benefits from a

single plant invariably requires greater management and labor inputs than conventional cropping. However, learning to tease more food from multi-use crops is another path to food security for low-income growers who can rarely afford more land, fertilizer, or machinery to increase their production.

Taro, Dasheen, Cocoyam, Eddoe - *Colocasia esculenta*
Tannia, Malanga, New cocoyam, Yautía - *Xanthosoma sagittifolium*
Belembe, Tannier spinach - *Xanthosoma brasiliense*

Though often grouped together with root crops, these edible members of the Arum (elephant ear) family, are actually grown for the starchy corms and cormels; swollen underground stems that hold undeveloped buds for forming new plants. They are also grown for the secondary value of their edible leaves. Belembe is the exception, having small corms and being grown almost exclusively for its leaves. The Colocasias likely originated in wetlands of southern India, while the Xanthosomas are native to swampy areas of the Amazon basin.

Although they are not eaten on a scale approaching potatoes, cassava, sweet potatoes or yams, taro, and tannia are important sources of calories throughout much of the humid tropics, especially in the Pacific islands. Like cassava, taro and tannia have chemical defense systems to

discourage animals from eating their roots and leaves. It is actually a combination of physical and chemical strategies that protects the aroids. Needle-sharp raphides, or oxalate crystals, puncture the skin of animals and allow an enzyme to react with soft tissue, causing swelling and soreness of the tongue, lips, and throat. Fortunately, thorough cooking defeats this defensive strategy, giving humans an advantage over non-cooking animal species.

Taro and tannia are tropical perennials. They prefer average temperatures in the range of 21–27° C (70–80° F), and fail to grow at temperatures below 15° C (60° F). All of the aroids are normally propagated from corms or cormels, or from sets formed by cutting the top 3 cm (1 in) of the corm together with about 12 cm (4–5 in) of petiole (leaf stem). The sets tend to produce roots more quickly than the corms. They also have the advantage of allowing most of the corm to be used as food, rather than for propagation.

Taro can be grown as an upland crop or a lowland crop. Lowland taro is grown in conditions similar to paddy rice and is normally planted at the start of the rainy season. It is generally grown more intensively, with higher planting densities and correspondingly higher yields. Upland taro needs consistently moist soil but not flooding. It is more shade tolerant than lowland taro and is often intercropped with maize or beans. Tannia is always grown

as an upland crop because it won't tolerate flooding, though it too thrives in consistently moist soil conditions.

Upland taro is ready for harvest in 8 to 9 months, tannier in 9 to 10 months, and lowland taro in 12 to 15 months. Taro yields are typically about one and half times greater than tannier. This is partly because most of the tannier corms are too fibrous to eat, so only the cormels are eaten. Despite this, tannier production is replacing taro in much of the world, especially in Africa. It is considered easier to grow, more adaptable to shade and low fertility soils, and more resistant to drought and disease.

The leaves and the leaf stems (petioles) are usually harvested casually with no noticeable reduction of corm yield. There are likely optimal harvest schedules to maximize the overall production of both leaf and corm, but little quantifiable research has been done to develop these schedules. Both the leaves and petioles have a mild pleasant flavor and, as noted earlier, both need to be well cooked before eating. The petioles are eaten somewhat like asparagus, though they offer little in the way of nutrition.

As with most multi-use crops, the leaves of taro are far more nutritionally dense than the starchy storage organs. On a dry weight basis the corms supply 20–25% more calories than the leaves. However, taro leaves provide roughly 7 times more protein, 8 times more iron, 5 times more

calcium, 12 times more folate, 20 times more vitamin C, and 70 times more vitamin A activity than an equal weight of the corms.

For both taro and tannier, leaf production is usually very strong until about 16 weeks after planting when plants focus on storing energy in their corms and cormels. In areas that have at least 16 weeks of warm weather, but not the 32 weeks or longer required for corm production, taro, and tannier could probably be grown, like belembe, as purely leaf crops.

One of the major obstacles to this strategy is the lack of vegetative planting stock outside of areas where the crop is traditionally grown. It is always easier and cheaper to transport seed to a location with a limited market than to transport stem cuttings, tubers, or corms. As gardeners and consumers become more adventurous, opportunities for specialty markets may present themselves to adventurous nursery businesses or non-profits involved in agriculture and nutrition. Propagation stock for tropicals grown just for their leaf crops could fall into this category. Their combination of mild flavor, impressive nutritional value and high yields make the leaves of edible aroids attractive targets for further development as vegetable crops.

Quinoa - *Chenopodium quinoa*

Quinoa is native to the foothills of the Andes Mountains, where it has been grown for over 6,000 years. Considered a

sacred plant by the Incas, quinoa production diminished greatly after the Spanish invasion. For the last 400 years it has been a relatively minor regional crop. Recently quinoa seed has gained popularity in the international health food market as an alternative to rice and other true grains (seeds of annual grasses). It contains more total protein (12–18%) and a better balance of essential amino acids than true grains, which are all deficient in lysine. Quinoa also lacks gluten, a protein in wheat that many people have an adverse reaction to. What is more, the starch granules in quinoa seed are very small and easily digested.

Along with spinach, beets, and Swiss chard, quinoa is a member of the *Chenopodium* family, and thus not a true grain (edible seed of the grass family). While the seed is by far the more important food, quinoa greens have also been eaten and appreciated wherever the crop is grown. Young quinoa leaves make a potheb nearly indistinguishable from the greens of the common weed lambsquarters.

Quinoa is a hardy crop, growing at elevations up to 4,000 meters (13,000 ft). It is tolerant of drought and saline soil, but produces much better with an even supply of moisture and deep, well drained soil. The seeds sprout very quickly and are protected from birds and other animals by a coating of bitter saponins. When the seeds will be used for eating, these saponins are removed

by rinsing or abrasion before the seeds are cooked.

Quinoa greens are rich in protein, iron, calcium, vitamin A and vitamin C. Unfortunately, like all the members of this family, quinoa also has relatively high levels of oxalic acid in its leaves, which makes its calcium less readily absorbed in the human body. Unless someone is genetically inclined to form kidney stones, a moderate amount of dietary oxalic acid in an otherwise adequate diet appears to be harmless.

Leaves for greens should be harvested before the plant flowers. Andean farmers thin overcrowded young plants and use the thinnings for greens. Careful partial harvest of leaves before seeds form will result in the highest total nutrient production for a given area. Optimizing systems for combined yield of quinoa leaf and seed harvest will likely depend on availability of labor and markets for the greens. Quinoa greens are usually eaten by the farmers as a fringe benefit or sold casually in local markets.

Grain Amaranth - *Amaranthus hypochondriacus*, *A. cruentus*, and *A. caudatus*

The name amaranth comes from a Greek word meaning “life everlasting.” This seems like an odd name for a plant family comprised mainly of about 500 fast growing annuals. Most of the world’s amaranths are used as leafy vegetables or as ornamentals, but in the western hemisphere

amaranth seeds became important staple foods. Two of the three amaranth species that have been grown for their grain, *A. hypochondriacus* and *A. cruentus*, are native to southern Mexico, while *A. caudatus* is native to the Andes region of South America. The grain amaranths were among the very first plants that were systematically improved by breeding. Mesoamerican children were given the task of sorting through piles of seed and separating out the occasional white seeds. These were grown in separate plots until varieties with only white seeds were developed. The white seeded amaranth had lower levels of tannin, and thus was milder tasting and more easily digested.

Like quinoa, grain amaranth production dropped sharply with the Spanish invasion of the Americas. It was estimated that 20,000 tons of grain amaranth were brought annually in tribute to Moctezuma, the Aztec Emperor in Tenochtitlan in the years preceding the conquest by Cortez. The Catholic Spanish banned the cultivation of amaranth because the ground amaranth seeds were sometimes mixed with human blood and shaped into snakes, birds, mountains, deer, or gods, and eaten during Aztec religious ceremonies

Grain amaranth is now making a modest resurgence in Latin America, and in North America and Europe, where it is a specialty health food product. The most intensive production of grain amaranth,

however, has shifted to northern India. The amaranth seed pseudo-grain is considerably richer in protein than the true grains, and the protein has a surplus of the essential amino acid lysine which is deficient in corn, wheat, and rice.

All of the amaranths employ the C4 photosynthetic metabolism. This is a variation on the photosynthetic system used by corn, sugar cane, sorghum, and other plants to maximize growth in hot dry climates with intense sunlight. Broadleaf C4 plants are rare, and this attribute gives amaranth unusual drought tolerance for a shallow-rooted plant. They will grow in a wide range of soils but prefer sandy soils with good drainage and a slight acidic pH. Most amaranths are sensitive to cold weather, but among the grain amaranths, *A. caudatus*, which developed high in the Andes Mountains, has some tolerance to cold.

The leaves of all the grain amaranths are eaten casually for greens. Sometimes the seed is over-planted and the thinnings are eaten as greens. *A. cruentus* has traditionally been grown as a combination leaf and seed crop. The Hopis in the US southwest developed brilliant red varieties that produced well in that hot dry climate. It can be planted densely and thinned for greens but also does well when the growing tips of the young plants are pinched off. This causes more lateral shoots to form and these too can be pruned for greens. Leaves can be harvested at any time until seeds

begin forming, and unless the partial leaf harvest is too severe, the plants recover to produce bountiful heads of edible seed.

Enough leaves for a meal can be harvested from a small patch of *A. cruentus* every 2 to 3 weeks, delaying the onset of seed formation. It is a crop with tremendous potential for gardeners and subsistence farmers because it can be adapted to so many different growing regimens. It is also easy to save *A. cruentus* seeds so that the cost of planting the following season can be eliminated. The plant often self-seeds the area where it grows, with numerous seedlings volunteering in clusters. These can be easily transplanted to achieve more desirable spacing of the new crop or allowed to grow until they are crowded, then harvested as potherbs.

Amaranth leaves are good sources of protein, calcium, iron, vitamin A, vitamin C and folate. Although the seeds are rich in protein—having more than any of the staple grains on a dry weight basis—the leaves are richer still, with three times as much protein as the seeds. Unfortunately, high levels of oxalic acid somewhat diminish the absorption of calcium. Amaranth leaves can also contain uncomfortably high amounts of nitrates, especially when grown with synthetic nitrogen fertilizers. Vitamin C, which is plentiful in the leaves unless they are overcooked, helps render the nitrate harmless. Boiling

amaranth leaves, then changing the water will also remove some of the nitrates.

Traditional Garden Vegetables with Edible Leaves

Most gardeners are unaware of specific leaf crops grown thousands of miles away in very different conditions. What is surprising is how few gardeners are aware that many of their traditional garden vegetable plants also have leaves that are tasty and nutritious. To make use of these edible leaves, a somewhat different perspective on gardening is helpful. Rather than viewing the vegetable garden as simply a place to produce food, it may be seen as a small but complex ecosystem. Gardening becomes a fascinating exercise in guiding the evolution of that place and integrating oneself into that miniature ecosystem.

Learning more about the lives of the plants and the lives in the soil, the gardener can begin seeing more things of hidden value within that ecosystem, making the garden both more productive and more interesting. Finding multiple uses for vegetable plants is one of the most important discoveries. There are no set rules for determining how the partial harvest of leaves affects the yield of beetroot, turnips, pumpkins, or onions. Mastering the integration of multi-use crops into the garden is an engaging mix of botanical science, agricultural craft and even a touch of artistry. Multi-use crops reward the observant and patient gardener.

The precautionary principle suggests that any new food added to the diet be eaten in small amounts to allow time to observe any possible allergenic or other adverse effects. Using younger leaves and cooking them provides an additional margin of safety.

Beets - *Beta vulgaris*

Beets are one of about 150 species of the Chenopodium family. Originally from the edges of the Mediterranean Sea, their coastal origin probably explains their high tolerance to salt in the soil. Ancient Romans raised beets mainly for the edible leaves. The use of the swollen beetroot appears later. Swiss chard and sugar beets are two familiar variations within the same beet species.

Beets are biennial plants that are almost always grown as annuals. They have deep taproots that offer some protection from drought. What we think of beet seeds are really hard dried fruits containing up to eight seeds. This accounts for their erratic germination patterns and the difficulty of getting uniform stands of seedlings. Beets can tolerate light frosts but grow best at temperatures between 16–20° C (60–70° F). They are somewhat more tolerant of hot weather than their relative, spinach.

Loose sandy soil is preferred for production of market quality roots, but heavier soil is fine for growing beet greens. A soil pH that is nearly neutral is ideal; yield is reduced in acid soils. Beets can be

planted every 5 cm (2 in) in rows 25–40 cm (10–16 in) apart. When they are 5–8 cm (2–3 in) tall or when they begin to look overcrowded, they may be thinned, and the thinnings eaten in salads or stir-fries. Beets are a good container plant as long as the soil is at least 30 cm (12 in) deep. They can be replanted every 3 to 4 weeks throughout the growing season to maintain a steady supply of small tender beetroots and greens.

The strong red color present in most beets and some beet greens comes from betacyanin. This pigment is thought to have cancer fighting properties, especially against colon cancer. This anti-cancer effect likely results from betacyanin increasing the activity of two powerful antioxidant enzymes in the liver. Beet juice is sometimes used as a natural food coloring, and though it is a very healthy food, can cause alarmingly red urine.

Beet greens can be grown as a separate crop or as a by-product of growing the roots. Beetroot yields are usually acceptable even when up to one-third of the leaves are carefully harvested for greens. Cold weather and nitrogen-rich soil favor production of leaves at the expense of the edible roots. Compared with their roots, beet greens contain more than triple the iron, seven times the calcium, six times the vitamin C, and 150 times the vitamin A activity. Beet greens have a slightly coarser flavor and texture than spinach, but they

can be prepared and enjoyed in most of the same ways.

Squash or Cucurbit family

Summer Squash, Winter Squash,

Pumpkins, Gourds - *Cucurbita pepo*

Winter Squash, Pumpkins - *Cucurbita mixta*, *C. maxima*, *C. moschata*,

Cucumber - *Cucumis sativus*

Chayote - *Sechium edule*

Bottle Gourd - *Lagenaria siceraria*

Fluted Pumpkin - *Telfaria occidentales*

Oyster Nut - *Telfaria pedata*

Bitter Gourd - *Momordica charantia*

Luffa - *Luffa cylindrica*

Wax Gourd - *Benincasa hispida*

Ivy Gourd - *Coccinia grandis*

The squash, or Cucurbitaceae, family has over 800 species originating primarily in Central and South America and secondarily in tropical Asia and Africa. They have been useful to humans both as food and as vessels for at least 10,000 years. Hard shelled gourds, along with coconuts, can stay afloat for months and thus were among the few food plants to have disseminated across the oceans without human assistance.

Most cucurbits are annuals that use tendrils to climb whatever nearby structure or plant is handy. Some, like pumpkins, have more of a low sprawling habit. A few varieties of edible squash have even been bred for the plant to have a compact upright bush form. Oyster nut and ivy gourds are perennials and can actually become

troublesome invasive plants in the tropics. They should be planted with great caution if at all, and not be introduced into areas where they are not already grown.

Although tropical in origin, many members of the squash family are quite well adapted to the temperate zone. None, however, have developed significant frost tolerance. They grow best with temperatures in the 25–30° C (77–86° F) and should not be planted until the soil is thoroughly warmed in the spring.

All of the squashes and gourds are heavy feeders that thrive in rich, well drained soil. Most do best with about 2.5 cm (1 in) of water a week, although some, such as buffalo gourd, have more drought tolerance. There are several important pests of the cucurbit family. These include squash vine borers, which are the larvae of small grey moths that infest the stems of squash plants; cucumber beetles and squash bugs. If the plants can be protected with floating row covers until they begin flowering, most of the insect problems can be avoided. It is difficult to keep climbing plants covered that long, but even a few weeks of early protection will greatly lessen insect damage. Sometimes moving the sowing date of cucurbits up or back by a week or two will reduce the intensity of insect attacks.

Cucurbits are grown for a variety of useful products. Immature fruits, such as cucumbers and zucchini, and mature

fruits, such as pumpkins and butternut squash, are the most familiar. The hard shelled gourds are used for ornaments, as containers of all sorts and even as resonators on stringed instruments. Loofahs are valued for the strong sponge-like fiber inside mature fruits, and are used for scrubbers and in filters, as well as for their immature fruits that are eaten like zucchinis. The seeds of many cucurbits are eaten informally, and pumpkin seeds are a well known and commercially marketed food. They are rich in oil and protein.

What is not at all well known, especially in Europe, North, and South America, is that the leaves of most cucurbit plants are edible and nutritious. Asian and African cultures value the leaves of fluted pumpkin, ivy gourd, chayote, oyster nut and bitter gourd among others and these will often be seen in local markets. They are almost always cooked and typically prepared in soups or sauces that add flavor, vitamins, and minerals to bland starchy staple foods, especially rice, maize, sorghum, millet, and cassava. Generally pumpkin leaves are not exactly delicious but neither are they unpalatable. The flavor of bitter gourd leaves on the other hand are, as the name would suggest, very bitter. Leaves that are bitter or mucilaginous are sometimes cherished in African and Asian diets.

There are several ways to produce edible leaves from the squash family. Plants grown just for leaves can be sown much more

densely than when grown for the fruits. Alternatively, they can be planted densely and repeatedly thinned until they reach a good plant density for growing pumpkins or squash, usually about 120 cm (4 ft) apart. In this case the thinnings are eaten for greens, leaving space for the few remaining plants to mature. This strategy works best when seed is cheap or plentiful and especially if you save your own seeds.

Plants can also be grown as they normally would be for fruits, with some limited harvesting of leaves. Light partial leaf harvest usually won't depress the yield of fruit. Another technique is to plant leftover seed late in the season when there is not sufficient time for fruit to form but there is still plenty of growing season for a good crop of leaves.

Turnips - *Brassica rapa* var. *rapa*

Turnips are an annual or sometimes biennial plant with a swollen storage root, that have long been used for food and fodder, and as described earlier, as a cover crop. Turnips are an ancient crop that traveled with Alexander the Great on his conquests. The Irish used them as jack-o-lanterns long before Americans replaced them with pumpkins for Halloween. They are one of the easiest of all crops to grow and they thrive in most climates and soil types. They are temperate zone plants but also do well in higher elevations in the tropics.

Turnips are really two nutritious vegetables in one: the smooth white or purple-topped roots and the leafy green tops. While some cultivars such as Shogoin are grown mainly as a leaf crop, and others, like Purple Top, are grown mainly for roots, most turnip varieties will produce good yields of both. They can be sown in early spring or in late summer for a fall crop. Seed is usually cheap, so it is feasible to broadcast turnips and thin them as they begin crowding each other, or to grow them as a cover crop.

Thinnings make excellent greens. While partial harvesting of leaves can somewhat reduce the yield of roots, turnips are such a productive, low maintenance crop that an abundant harvest of both greens and roots is within the reach of even novice gardeners.

Both parts of the turnip are nutritious vegetables, but again the green leaves outperform the roots. Turnip greens are one of the best sources of the beta-carotene that is converted to vitamin A, while the roots lack this nutrient. Compared to the roots, turnip greens also have 3 times the iron and vitamin C, 6 times the calcium, and 13 times the folate.

Radish - *Raphanus sativus*

Radishes are annuals in the mustard family, usually grown for their edible swollen roots, though some varieties are used for fodder and cover crops. They originated in the area around the Caspian Sea, and spread rapidly

along trade routes. Radishes are now grown nearly worldwide, though they favor cooler locations. They range from the size of a small marble to that of a basketball, and their shape varies from spherical to long and slender. Small radishes can be sown at the first sign of spring and harvested 3 to 5 weeks later. The larger Asian varieties usually take about 8 to 10 weeks from sowing till harvesting. Radishes must grow rapidly with abundant soil moisture or the roots can become tough and harsh flavored. They are sometimes interplanted with lettuce or carrots.

Smaller radishes are usually eaten raw while the larger ones may be stir-fried or used in soups. They all share the characteristic sharp flavor of horseradish and mustard, derived mainly from sulfur-bearing compounds called glucosinolates. These are primary cancer fighting phytochemicals and give radishes a potentially important role in preventive health care.

Though not nearly as popular as beet or turnip greens, the leaves of radishes make a passable potherb. The raw leaves are a bit furry but even brief cooking eliminates the leaf hairs or trichomes. One of the good things about radishes as a multi-use crop is that there is little conflict between the use of the leaves and the yield of the roots. Because the roots are grown more for crispness than maximum size, the leaves can just be harvested together with the roots, and then prepared separately. Radish leaves

have about 6 times more vitamin C than the roots, and substantially higher levels of vitamin A, folate, calcium, and protein.

Onion - *Allium cepa*

Onions are a nearly universal food originally from Central Asia. While generally cool season vegetables, some varieties are adapted to the tropics as well. Onions and garlic are members of the lily family. Although there are several perennial members of the onion family, the common bulb onion is a biennial almost always grown as an annual. Onions can be started from seeds, sets, or bulbs. The onion bulb is actually comprised of the swollen bases of leaves. Above the bulb 3 to 8 leaf blades form. They are hollow and grow nearly vertically.

Dry and cool conditions favor optimal growth of both leaves and bulbs. Onions grow well on soil pH from 5.6 to 7.0, but abundant soil calcium is needed to improve disease tolerance. Rotating the location of onion planting every year helps prevent common fungal diseases. Usually the best quality and longest keeping onion bulbs are obtained by planting seed, but crops can develop several weeks faster from planting sets or tiny bulbs. Onions have shallow roots and compete poorly with weeds. For this reason frequent shallow cultivation or a layer of mulch is beneficial.

After five hollow leaves have formed, some leaves can be snipped off to use as greens with little damage to bulb

production. There is no sure formula for knowing how much leaf can be harvested before bulb yield declines unacceptably. It is relatively easy to experiment with two or three small onion patches to get a feel for it. The total yield of useful vegetables from combining partial leaf harvest with bulb harvest will always exceed bulb yield alone. Cut the leaves cleanly rather than tearing them off in order to minimize bacterial or fungal problems.

Leftover onion sets can be planted densely in containers to provide a nearly continual supply of onion leaves for flavoring dishes or to spice up salads. Any surplus of onion leaves can be easily dried and later used as flakes or powder to add to sauces and other dishes. Some West African cultures cut all the leaves that are still green at bulb harvest and pound them into a pulp that is then fermented and sun-dried for use later in seasoning stews and soups. Drying the leaves quickly but out of sunlight will preserve much more of the beta-carotene.

Recognizing the value of the onion's green leaves increases the already impressive culinary adaptability of this vegetable. They are an excellent source of vitamin A and supply roughly twice the calcium, iron, vitamin C and folate as an equal weight of onion bulbs. Onion leaves stimulate the body's production of glutathione, a key cancer fighting antioxidant.

Garlic - *Allium sativum*

Garlic is thought to have originated in semi-arid parts of Central Asia, and growing garlic in Egypt dates back nearly 4,000 years. It is now grown throughout most of the world. Garlic is a close relative of onion, with a distinctive pungent flavor and aroma. China and Korea produce over 70% of the world's garlic. There people eat enough garlic to consider it a vegetable, rather than a flavoring agent.

While primarily used as a flavoring for a great many dishes, garlic also has a rich history of use as a botanical medicine. Unlike many herbal medicines, garlic has held up well to scientific investigations. Among documented effects, garlic inhibits bacterial and fungal infections, lowers blood cholesterol, and reduces the risk of stomach cancer

Garlic forms a bulb, somewhat like onion, except that it is normally comprised of a cluster of 5 to 20 cloves. It is propagated by planting the cloves. Garlic prefers a light loam soil and, like onion, does not compete well with weeds. Frequent shallow weeding or mulch will increase yield. It is susceptible to soil acidity and aluminum toxicity.

As with onion, the green leaves provide the garlic grower with a bonus vegetable. Little is written about the optimal strategies for combining a harvest of leaf and bulb. The leaves will have greater nutritional value for the same weight, especially of vitamin A. They contain most of the

compounds that give garlic its characteristic flavor and its medicinal properties. Garlic leaves are easy to dry, and powdered garlic leaves make an excellent addition to the kitchen spice rack. Combining garlic leaf and bulb harvest is another productive food strategy waiting for more experimentation.

Bell and Chili Peppers - *Capsicum annuum*

Bird Peppers - *Capsicum frutescens*

Aromatic Hot Peppers - *Capsicum chinense*

Capsicum annuum is a plant species with a huge variety of fruits, ranging from the sweet and bland to fiery hot. All of the *Capsicum frutescens* and *Capsicum chinense* varieties are spicy hot. All three species along with about 22 other related pepper species evolved between southern Mexico and the Amazon region. The three primary species have been crossed numerous times both naturally and through cultivation. As a result many intermediate forms occur and the lines separating species and varieties of peppers have become blurred. Bell (sweet) peppers are mild flavored vegetables used in salads and a variety of cooked dishes including stuffed peppers. Sweet pepper is eaten in large enough quantities to be considered a vegetable, while the spicier peppers are eaten in smaller quantities as a condiment or spice.

Sweet peppers are adapted to somewhat cooler conditions than hot pepper, but all the peppers are heat loving, frost sensitive

plants. They can be grown in partial shade though this may delay fruit formation. They prefer slightly acid, well drained soils and are somewhat sensitive to waterlogging and to soil salinity.

The young pepper leaves can be used in soups and stews. A chicken stew called tinola in the Philippines is probably the most famous dish employing pepper leaves. Only modest amounts of pepper leaves should be eaten as they contain two mildly toxic compounds.

Common Okra - *Abelmoschus esculentus* or *Hibiscus esculentus*

West African Okra - *Abelmoschus caillei*
Okra is an annual plant in the hibiscus family. A native of Africa, it came to the Western Hemisphere with the slave trade and has now established itself in many of the world's tropical and sub-tropical regions. Okra is particularly popular in West Africa, India, the Philippines, Thailand, and Brazil. It is almost always grown primarily for its mild flavored, famously mucilaginous immature fruit. However, edible oil has been extracted from the seeds, and use of okra leaves as a potherb is fairly common.

The plant is very tolerant of heat and drought and is rarely damaged by insect pests. It adapts to different soils but the ideal is a slightly acidic, well drained, sandy soil with plenty of organic matter. Okra usually will thrive as long as it gets full sunlight and adequate water in its first few

weeks, but it is a tropical plant that won't tolerate frost. In Africa growers tend to prefer common okra in dry areas and West African okra in wetter climates.

Okra seed has a tough coat and will germinate much better if it is soaked overnight before planting. It needs warm conditions for good germination and early growth. Seeds can be planted 1–2 cm (1/2 in) deep and 5 cm (2 in) apart in rows and thinned two or three times as they begin to crowd each other. The thinnings can be eaten in soups or stews. It is helpful to have single rows of okra so that it is not necessary to reach across plants to harvest. This is because the okra plant defends itself by covering all of its parts with trichomes that contain enzymes that can irritate the skin of some people. About one third of all gardeners are sensitive to these enzymes and do well to wear gloves and long sleeved shirts when working with okra plants. Brief cooking neutralizes these defensive enzymes in both the pods and the leaves.

When growing okra for its edible leaves, it can be planted more densely and the leaves continually harvested as they compete for space. The most attractive strategy for gardeners and small subsistence farmers, however, may be to partially harvest the leaves for potherbs but not so aggressively that pod formation is prevented. As with many multi-purpose crops a harvest schedule can favor either leaf or fruit and developing an optimal

combination of leaf and fruit harvests will require some experimentation. If done carefully, partial leaf harvesting may delay fruit harvesting somewhat without significantly lowering the yield. The total yield of protein and most other nutrients will always be higher from a combination leaf and fruit harvest than from harvesting only okra fruits.

Okra leaves are a bit coarser than spinach but can be used in most any recipe calling for greens. They have a slightly tangy flavor from oxalic acid and are often used to thicken soups and stews. Okra leaves can be dried and powdered for use as a nutritious thickening agent. They are extraordinarily rich in calcium and could be a useful vegetable source of this nutrient in communities where dairy products are not widely eaten. Okra is a thrifty self-reliant plant with edible pods and leaves, and as if that were not enough, dazzling yellow to reddish flowers.

Bush okra, Jute Mallow, Jew's Mallow, Tossa Jute, Mulukhiyah, Molokhia - *Corchorus olitorius*

Bush okra is not related to okra or West African okra except in name. It is an annual plant that is probably native to Africa that is grown as a source of jute fiber. It is also a leading leaf vegetable in much of Africa and is also widely grown and eaten in the Caribbean, Brazil, India, Bangladesh, China, Japan, and the Middle East. It can grow over 2 meters (6 feet) tall but is usually

pruned to keep at a convenient height for harvesting. Varieties of this plant grown for jute fiber are quite different from the leaf vegetable varieties and can grow up to 5 meters (16 feet) tall.

Bush okra flourishes in hot and humid conditions. It stops growing at temperatures below 15° C (59° F). Because it is a fast growing plant good harvests can be obtained in warmer temperate regions as well throughout most of the tropics. In Kentucky, USA, at 37° north latitude, it thrives especially if started with some protection a couple of weeks earlier than other frost sensitive plants. At least 600 mm (24 inches) but not more than 2000 mm (79 inches) of rainfall is ideal. It prefers sandy loam soils rich in organic matter and grows poorly on heavy clay.

Bush okra can be directly seeded in the garden or grown from transplanted seedlings. Typically, transplanted bush okra is harvested by repeated cuttings, while direct-sown plants are harvested just once. The single harvest can be done either by uprooting or cutting at ground level when the plants are 30–40 cm (12–16 inches) tall. Transplanted bush okra is usually pruned at a height of 10–20 cm (4–8 inches) above the ground. This stimulates the development of side shoots. The first harvest (4–6 weeks after transplanting) is taken by cutting shoots 20–30 cm (8–12 inches) long. Subsequent harvests may be taken every 3 weeks, up to 8 times.

Bush okra is generally not bothered much by insect pests but is very susceptible to root-knot nematodes. Allowing adequate spacing for good air movement between plants reduces the likelihood of viral or fungal attack. Yields depend greatly on the soil fertility but repeated harvesting consistently out produces the all at once harvest.

Bush okra leaves are very perishable and are usually sold the day they are harvested or dried for later use. They have a slightly bitter flavor and are somewhat mucilaginous, like okra. The leaves either fresh or dried are valued for their ability to thicken soups and stews. It is one of the most nutritious vegetables, being especially rich in iron, calcium, beta-carotene, and vitamin C.

TROPICAL ANNUAL LEAF CROPS

Quail Grass, Soko, Lagos Spinach, Nigerian Spinach –*Celosia argentea*

Quail grass is closely related to the amaranths. Originally from West and Central Africa, it is widely grown as a nutritious potherb and as an ornamental throughout much of the world. It is especially popular as a vegetable in West Africa where it is often sold in half kilo bundles in the markets.

Quail grass prefers a soil rich in organic matter. Like amaranth it is frost sensitive. In fact, quail grass grows poorly at temperatures below 20° C (68° F) so it is not suited to most high elevation tropical gardens.

Unlike amaranth, quail grass uses the C-3 photosynthetic pathway which makes it much better suited for growing in partial shade.

Quail grass seed can be broadcast, but the seed is tiny and it is difficult to get an even stand of plants that is not overcrowded. Transplanting seedlings from a starting bed or from volunteer plants results in better yield and easier management. The transplants can be set at about 15 cm (6 inches) apart in all directions. The plants can be uprooted 4 weeks after transplanting, or pruned to encourage growth of side shoots. Four or five harvests can usually be made at two week intervals before flowering begins. Yields are generally lower than those of amaranth.

Quail grass is less bothered by insects than amaranth. In hot humid conditions it is somewhat prone to fungal disease. Root knot nematodes can also be a problem, although adding organic matter to the soil reduces the damage.

Quail grass is always cooked and the flavor is better when the cooking water is discarded. It is a good source of iron, vitamin A and vitamin C. Unfortunately, oxalic acid reduces the nutritional value of the minerals in quail grass. Preliminary tests with the leaves and the seeds of quail grass have shown some promising anti-viral properties as well as potential lowering of blood sugar. It is extremely easy to grow and a very attractive plant.

Amaranth, Joseph's Coat, Tampala*–Amaranthus tricolor*

Native to South Asia, Amaranth tricolor is an annual leaf crop that was domesticated in prehistoric times. It grows quickly up to a meter high. Varieties with bright red, yellow, and green leaves are grown throughout the world as ornamentals. Like sugar cane, it uses the C-4 photosynthetic pathway which makes it especially efficient at producing food in bright sunlight and high temperatures.

Amaranth grows best in well-drained soils rich in organic matter. It is frost sensitive and doesn't do well in cool or shady conditions. It requires a steady supply of water and may flower prematurely if the soil is allowed to dry out completely between rains. Soluble nitrogen fertilizers should be avoided because amaranth can become excessively high in nitrates.

Amaranthus tricolor usually germinates in 3–5 days and begins flowering in about 5 weeks. Seed is normally either broadcast thinly over a bed or sown in narrow rows, 12–24 cm (5–10 inches) apart. Seedlings are very susceptible to damping off and don't transplant well. The bed may need to be weeded once before the amaranth creates its own cover. It is subject to attack by a fairly wide range of insects, though nematodes and viruses are rarely a problem.

Where it is grown commercially amaranth is usually uprooted or cut at ground level after 3–4 weeks. Pinching

the lead stems will cause it to branch out and will increase the number of partial leaf harvests and the total yield. Yields can be up to 200 kg of edible greens from a 10 square meter garden bed (440 pounds from 100 square feet).

Amaranthus tricolor is very nutritious as a cooked leaf vegetable. It is rich in protein, iron, calcium, magnesium, vitamin A and vitamin C. Oxalic acid content can limit the availability of minerals. Nitrates can be kept lower by removing stems and not growing with synthetic nitrogen fertilizer. Unless more than 200 grams (about one half pound) per day is consumed these anti-nutrients are unlikely to be a problem.

Spiderplant, Cat's Whiskers, Spider Flower, Bastard Mustard *–Cleome gynandra*

Spiderplant or cat's whiskers is an annual herb growing up to 150 cm (60 inches) tall. It probably originated in south Asia, but is now grown as a vegetable and as an ornamental throughout the world. The young leaves are especially popular as a potherb in southern Africa.

Spiderplant prefers soil that is slightly acid, well-drained and relatively rich in organic matter. It won't tolerate frost and doesn't grow well below 15° C (60° F). Because it uses the C-4 photosynthetic system spiderplant thrives on intense sunlight and high temperature and is not very shade tolerant.

It is often grown from volunteers that can be transplanted when they are very young to achieve optimal spacing. When spiderplant is sown it is usually grown in rows spaced 30–60 cm (12–24 inches) apart. Seeds germinate in 4–8 days. Three weeks later they can be thinned to about 10–20 cm (4–8 inches) between the plants. Spiderplant is slightly prone to powdery mildew and is frequently attacked by aphids, flea beetles, and nematodes. On the other hand it repels some insects and has been intercropped with beans and cabbage family plants to reduce the damage they suffer from diamond back moth larvae and thrips.

Leaves are usually harvested by pruning the growing tips every two weeks. This encourages more side shoots and increases the total yield. Harvest can be extended by supplying plentiful water and shading the plants. Older leaves develop a strong bitter flavor, so harvest is focused on young leaves. With careful management a yield of 3 kg of fresh leaf per square meter (7 pound in 10 square feet) of garden is feasible.

Spiderplant leaves are rich in protein, iron, and calcium. They often cooked with milk, peanuts, or mixed with milder flavored greens to make the flavor more appealing. The leaves are frequently dried for use when fresh leaves are hard to find. Most often they are blanched or boiled then formed into small balls before sun drying. The balls of dried leaf are soaked for several

hours before being added to soups. Much of the nutritional value is lost in preserving the leaves this way. An improved, but still simple, indirect drying process could make spiderplant a more valuable food. It is very easy to grow, has attractive flowers and is an excellent source of dietary iron.

African nightshade, black nightshade, garden huckleberry – *Solanum scabrum*

African nightshade is an annual plant in the same family as potato, tomato, and eggplant. It originated in the humid lowlands of West Africa where it is a popular potherb grown mainly in home gardens. It is most often used to flavor starchy staples such as maize, cassava, plantains, sweet potatoes and yams. It has a somewhat bitter flavor due to alkaloids, especially the mildly toxic solanine.

African nightshade prefers a warm humid climate and doesn't tolerate frost. Germination of seeds is spotty. Because of this it is often started in seed beds and later transplanted. It can also be propagated by stem cuttings, although plants started this way are not as strong. Transplants or cuttings are typically spaced every 20 cm (8 inches) in rows about 30 cm (12 inches) apart. In very humid conditions wider spacing is sometimes used to reduce the risk of fungal and bacterial disease.

Nightshade is prone to many of same diseases as tomato, including early and late blight. It can also be eaten by ants, grasshoppers, aphids, and nematodes. Sifted

wood ashes are often used to control insect damage. Commercial nitrogen fertilizer should be avoided to prevent high levels of nitrate in the leaves.

Harvest typically begins 5 weeks after transplanting. Shoots are pruned to encourage the growth of side shoots. Leaves can be harvested 3–6 times at an interval of about ten days. The shoots and leaves are very tender and perishable. Sometimes whole plants are uprooted and the roots put under water to keep them looking fresh in the market.

African nightshade is popular in West and Central Africa, but the reality is that there are other leaf crops available that offer greater benefit. It has good levels of beta-carotene and calcium but little iron or other minerals and vitamins. Because of the bitterness it needs to have its cooking water refreshed. Difficulty in germination may be another limiting factor in its wider acceptance.

Glossy nightshade, Hierba Mora

–*Solanum americanum*

Probably native to South America, glossy nightshade is now widely distributed throughout the tropics. It is less popular in West Africa but more popular in Latin America than African nightshade. The two plants are very similar to in most respects. The two are often mistaken for each other, as well as for other related members of this family with edible leaves. The confusion is

partly due to the casual use of overlapping common names.

Glossy nightshade is often gathered from wild stands. When it is cultivated it is mainly grown in coastal lowlands and around the edges of lakes and rivers. It prefers hot humid weather and won't tolerate frost. It will grow in partial shade but not as vigorously as it does in full sunlight.

It is normally started from seed in beds and then transplanted with a spacing of 30 cm (12 inches) in each direction. If it is kept pruned, side shoots can be harvested up to 6 times before the plant flowers. The bitterness increases as the leaves get older. Millipedes, snails, locust, and aphids have been reported to be pests of glossy nightshade.

Although generally less bitter than African nightshade, it is still too bitter to be appealing to children. Changing the cooking water helps somewhat. Glossy nightshade is often mixed with amaranth greens, milk, peanuts, or sesame to reduce the bitterness. The fruits, especially before they ripen, are considered inedible due to high levels of alkaloids. Its nutritional composition and productivity are similar to African nightshade. Both of these leaf crops would have greater potential use in the diet if stable varieties with lower levels of solanine were developed and made commercially available. Most of the work

with breeding that is currently being done is very casual and local in nature.

Perennial Leaf Vegetable Crops

Most plants are either annuals or perennials. The bulk of our diet comes from annuals such as rice, corn, wheat, squash, and peas that normally live for one year and need to be replanted the next. Perennial plants are ones that live for more than two years.

Every serious attempt at designing a more durable food system includes a much larger role for perennial food plants. Perennial crops offer several important ecological advantages. They usually have deeper, more extensive root systems than annual plants. This means they are better at preventing soil erosion, and better at securing scarce water and nutrients from deep in the subsoil. Once established, perennials are usually able to compete better with weeds than annuals. Because their roots and stems are already established, perennials spend a much smaller percentage of their lives in the vulnerable stage of tender seedlings.

The biggest advantage of perennial food crops is that the agricultural soil doesn't need to be tilled every year to prepare new seedbeds. In recent years, "no till" seedbed preparation techniques have become more popular for annual crops, but they generally depend on massive applications of herbicide. Perennial crops can drastically reduce the cost of seed and the expense of tilling

the land. More importantly perennial crops protect the farm or garden soil year round from rain, wind, and sun damage. Soil erosion must be minimized to ensure long term food production capacity. The rate of loss of prime agricultural soil at the beginning of each cycle of annual food crops is hundreds or thousands of times faster than the rate at which that soil is created.

With these significant advantages, why don't perennials play a more important role in our food systems? Agriculture began with the collecting and selective breeding of annual plant seeds. Seeds, especially the seeds of annual grasses, became the basis of agricultural civilization because they are nearly complete nutritionally, they can be stored for long periods of time, and they are compact enough to justify transporting.

Because their reproductive cycle is faster it is generally much easier to breed new varieties of annual plants than perennials. Centuries of selective breeding have created annual crops with the humanly edible portion maximized. Other economically useful traits, such as lack of bitterness and uniform height and time of ripening, have also been bred into annual crops. Perennials, especially tropical perennials, have more often been left in a semi-wild state with larger and more unpredictable genetic variations. As agriculture became more mechanized and foods became international trade commodities, breeding efforts focused on high yield and suitability

for machine harvest, while soil erosion has been largely an externalized cost.

Another reason for the dominance of annual leaf crops comes from colonial history. While Europeans were quite enthusiastic about exotic tropical fruits, even to the point of trying to raise pineapples under glass, they were less appreciative of tropical leaf crops. Much of the breeding effort with vegetables was aimed at making familiar temperate zone annual vegetables more available in the colonies, rather than testing new possibilities. The underlying assumption was that civilized people ate cabbage, lettuce, and spinach with their roast beef and potatoes, not exotic perennials like katuk, chaya, and chipilin. Regrettably this colonial attitude towards vegetables has been internalized in many of the tropical cultures, and traditional European temperate vegetables often retain a higher social status than local perennials.

So what can be done about this now? There are a few things that can be undertaken on the individual level to enlarge the role of perennial leaf crops in the temperate zone. The first of these measures is to acknowledge and make some use of the good temperate perennial leaf crops that we already have. Some of these, like nettles, sorrel, Good King Henry, and watercress are relatively well known. Others, such as wolfberry, musk mallow and linden, are eaten mainly by a relatively small clan of foragers, permaculturalists, and

ethno-botanists. Eric Toensmeier's book *Perennial Vegetables* is an excellent jumping off point for learning about temperate zone perennial leaf crops.

Another strategy for bringing perennial leaf crops to the world's temperate zones is to select and breed more cold hardy varieties of promising tropical crops. This will likely require institutional backing and patience, but it may be a productive strategy in the long run. Publicly supported university departments and government agencies along the southern edge of the temperate zone are in a position to do this work. A good starting place would be to screen varieties that had naturally adapted to cooler climates in the higher elevation of the tropics. There is enormous potential in breeding more cold hardy tropical perennials. Not only are there vastly more plant species in the tropics, but far greater genetic variation remains and as a result, more potential for plant breeding exists.

In addition to attempting to adapt tropical perennials to cooler climates, efforts are under way to directly convert annuals into perennials. This means finding keys to reverse the process that transformed perennials into annuals. It is thought that many annual food crops were originally perennials, as is likely the case with teosinte evolving to become maize. On the molecular biology level, researchers in Belgium have recently announced the discovery of two genes in annual plants that

when deactivated transform the plants into perennials.⁴ It is far too early to tell what, if any, impact this breakthrough will have on leaf crops.

Let's look at some of the best perennial leaf crops and how to integrate them into more sustainable local food systems.

TROPICAL ZONE PERENNIAL LEAF CROPS

Moringa, Horseradish tree, Drumstick tree - *Moringa oleifera*, *M. stenopetala*

Moringa is a multi-use tropical tree that has attracted attention from groups working in public health and nutrition. *Moringa oleifera* is a native of India but has now spread to most of the world's lowland tropical regions. *Moringa stenopetala* is originally from Africa and is much less well traveled. This African native has larger, somewhat milder flavored leaves. It is more drought resistant but also slower growing than its Indian cousin. Both plants can thrive up to about 2,000 m (6,000 ft) elevation, but typically do better with warmer tropical climates. There are several other *moringa* species but these two are by far the most important.

Moringa is quite adaptable to different soil types. Both types are drought resistant trees but neither will tolerate waterlogging.

⁴ Siegbert Melzer, et al., "Flowering-Time Genes Modulate Meristem Determinacy and Growth Form in *Arabidopsis thaliana*" *Nature Genetics* Volume 40 Number 12 December 2008 p. 1489 - 1492

Like most plants, *moringa* will produce far more foliage when grown in soil with adequate organic matter, nitrogen, and phosphorus.

Moringa has relatively few problems with disease and pests, though it can be attacked by termites and leaf cutter ants. It usually recovers quickly from having its leaves eaten by caterpillars or beetles. Its leaves are palatable to most animals, and young plants may need protection from cattle, sheep, pigs, and goats.

If *moringa* is grown for seeds as well as for leaves the spacing can be as wide as every 3–4.5 m (10–15 ft). It makes a pretty yard tree, that lets enough light through its branches to grow vegetables or herbs underneath. If the *moringa* tree is not pruned it can quickly become too tall for easy harvesting of leaves or seed pods.

Moringa is grown in India primarily for its immature triangular seedpods called drumsticks, but that it just one of the many valuable products from this tree. The mature seeds are the source of ben oil, a high quality edible oil. *Moringa* seeds are also useful in purifying water. The crushed seeds act as a flocculent, like alum, that clumps impurities together, greatly improving the efficiency of filtration.

Moringa roots, before they become too tough and woody, have traditionally been grated and used as a substitute for horseradish. In fact horseradish tree is one of its most common names. It is one of the

few plants outside the cabbage or mustard family that contains sulforaphanes, a class of powerful cancer fighting antioxidants that impart a sharp horseradish flavor. The bark covering the roots should always be discarded before use and horseradish made from moringa root should only be eaten in moderation.

Overriding these many uses is the enormous nutritional potential of moringa leaves. They are arguably the most nutritious single vegetable on the planet. This would be sufficiently impressive except that moringa leaves can also be one of the highest yielding and one of the most easily grown vegetables, especially in those regions with the highest levels of malnutrition. Although moringa has been known as a minor food crop for many years it is only now getting the full attention of international development agencies, agricultural research institutions and food processors. The value of a highly adaptable perennial crop with all these attributes can hardly be overstated.

There are several approaches to growing moringa primarily as a leaf crop. It can be started from seed, from transplants or from stem cuttings. Most growers think that starting from seeds results in healthier plants with deeper root systems than starting from cuttings. However, stem cuttings are relatively simple and are a faster way to get productive moringa plants growing, especially when seed is limited.

Cuttings should be 25–50 cm (10–20 in) long and taken from hardened wood at least one year old. The cuttings should be dried for three days and then planted to a depth of one-third of their length. Cuttings can be grown in containers for 2 months before transplanting into the field.

If you have plentiful seed, rich soil and water available for irrigation, moringa can be planted densely-up to one seed every 10 cm (4 in) in all directions. This extremely high planting density can maximize yield but may result in more trouble with fungal and viral disease. Planting one seed every 20 cm (8 in) in rows 46 cm (18 in) apart results in a strong stand that can be harvested for leaves every three weeks, without requiring quite as much seed. When grown as an intensive leaf crop the leading tip (apical meristem) should be clipped off when the plant gets over three feet high, and side branches should be clipped off at a length of 60 cm (2 ft). This encourages vigorous branching, maximum leaf production and easy harvesting.

The yield of intensively grown moringa leaf can be impressive. Biomasa, a European development group working in Nicaragua, reported yields of about 275 metric tons of green leaf and stem per hectare (250 tons/acre). Typically yields will be far lower where soil fertility, irrigation, or pest control is not optimal, but there is clearly potential for huge yields. These sorts of yields would allow moringa to be used

not only as a leaf vegetable, but also for making leaf concentrate. It could also be used as animal fodder, as a soil-improving cover crop or for producing biogas.

Moringa leaves are small and easily stripped off the stem. In addition, they have lower moisture content than most other leafy vegetables. All three of these factors make them easy to dehydrate in solar food dryers. It is important to sift the stems from the dried moringa carefully, as any remaining dried stems are extremely tough and can be unpleasant in your food.

Dried moringa leaf powder can be incorporated into hundreds of local foods throughout the world. A rounded tablespoon of this powder could supply a young child with all the vitamin A and more than half the iron they require each day at a low cost. The tablespoon of moringa leaf powder could also provide a significant contribution to the child's requirement of calcium, protein, potassium, magnesium, and vitamin C. Moringa leaves also have one of the highest ORAC scores of any vegetable, which indicates effective antioxidant properties.

Chaya, Tree Spinach - *Cnidoscopus aconitifolius*, *Cnidoscopus chayamansa*
Chaya is a perennial shrub native to the drier part of southern Mexico, Along with cassava and poinsettia, it is in the Euphorbia family. The wild forms of chaya have stinging trichomes on the leaves and should only be harvested with gloves.

Domesticated varieties have leaves that are much less irritating.

Cultivated varieties rarely produce viable seed so they are propagated almost entirely by stem cuttings. Cuttings should be taken from hardened woody stems and be at least 15 cm (6 in) long. They are easily rooted in damp soil. The stems should be dried for a few days and planted with the top of the cutting sticking about two-thirds of the way out of the soil. The stem cuttings can be started directly in the garden or field or transplanted out once they have developed a root system. Once established, plants are very drought resistant. There is more danger from overwatering and waterlogging than from drought. Chaya is not much bothered by insect attacks and the damage is usually repaired quickly by new leaf growth.

The yield potential of chaya is high. When grown intensively, it can produce up to 24 metric tons per hectare (11 tons/acre) of dried leaf every year. A single hectare in intensive chaya could provide about 3,200 children with 20 g (about 2 tablespoons) of dried leaf powder every day. Despite its promise as an intensively grown leaf crop, chaya's potential may be greatest as an attractive yard shrub that can supply a family with nutritious leaves for meals year round. Chaya shrubs are often pruned back for easy harvesting and to encourage the growth of side shoots, which increases leaf yield.

Because raw chaya contains compounds that release toxic hydrocyanic acid (HCN), chaya leaves should always be cooked for at least 5 minutes. The levels of HCN are far less than in cassava leaves and chaya leaves usually have no are detectable HCN after boiling for 5 minutes. Shredding or pulping chaya leaves before drying them will speed the escape of HCN. Dried chaya leaf is probably best eaten in dishes such as soup or pasta, where it is brought to a boil again to further eliminate any possible danger of HCN.

Chaya is one of the most nutritious of all leafy vegetables, with high levels of protein, iron, calcium, vitamin A and vitamin C. Compared to spinach, chaya contains nearly double the protein and vitamin A, four times the calcium, and seven times as much vitamin C. Some preliminary studies have suggested a possible role for chaya leaves in combating diabetes.⁵

Vine Spinach, Malabar Spinach, Ceylon Spinach - *Basella alba*, *Basella rubra*

Vine spinach is a perennial plant with mild flavored, somewhat mucilaginous leaves. *Basella alba* refers to green stemmed varieties and *Basella rubra* to varieties with reddish stems and leaves, but they are essentially the same species of plant. *Basella*

is native to south Asia, the word apparently from the Sinhalese language of Sri Lanka.

Basella is a heat loving tropical that grows slowly, if at all, in cool weather and is easily killed by frost. It shouldn't be planted outdoors until night temperatures are consistently warm. Vine spinach can be grown in the warmer temperate zones, especially if it is given a head start of a few weeks in a greenhouse or cold frame. It tends to start slowly but then grow very quickly once the weather becomes too warm for other greens. It will survive in most soils but does best in rich soil with high organic matter content.

Vine spinach can be planted as close together as one inch, depending on how the trellises are arranged. When planted that closely it will need to be thinned to allow one or two strong plants every foot or so. The thinnings make good salad greens. Vine spinach can be propagated by stem cuttings as well as seed, and will often spontaneously form new roots where the plant touches soil. A few pieces of stem at least 15 cm (6 in) long may be started in potting soil so that some plants are ready to transplant into the garden when it starts getting too hot for cool weather crops.

Vine spinach is an attractive plant most often grown on trellises or fences. It can be grown without a trellis, but it has a strong vining habit and forms a somewhat tangled mess if allowed to run freely on the ground. Leaves grown on trellises are much less

⁵ Kuti, J. O. and E. S. Torres. 1996. Potential nutritional and health benefits of tree spinach. p. 516-520. In: J. Janick (ed.), *Progress in new crops*. ASHS Press, Arlington, VA.



Katuk (*Sauropus androgynus*)

likely to be contaminated by soil bacteria from splashing rain. This is especially important when the leaves are eaten raw in salads. A variation is to grow vine spinach in hanging baskets and harvest the stems before they reach the ground. It is especially important that basella growing in containers be watered regularly.

After three or four weeks of growth basella will benefit from harvesting of

leaves and stem as often as every ten days, as this stimulates the growth of new shoots. Basella is surprisingly free of insect pests for a plant with such tender leaves and stems, though it is prone to nematode damage in soils that are infested.

In Kentucky, USA, with a six-month growing season, the smaller leafed *B. rubra* reliably produces viable seed and plentiful volunteers the following spring, but the larger leafed *B. alba* is killed by frost before its seeds are mature. The red stemmed *B. rubra* produces edible leaf in early and midsummer, while the green stemmed *B. alba* does most of its leaf production in late summer and early fall.

Yields of basella vary a great deal depending on the climate, the soil, and cultivation techniques employed. High yields are possible and yields of 161 metric tons of greens per hectare (72 tons/acre) have been recorded in a six-month growing season. Basella is too mucilaginous to use as a source of leaf concentrate. It becomes foamy when pulped and the juice is hard to separate from the fiber. It is certainly possible to dry vine spinach leaves, but it is more difficult than drying leaves that are not mucilaginous and that have lower moisture content, such as moringa.

Basella is mild flavored and even after flowering begins, the young leaves are tender and mild enough to eat raw in salads. It is often cooked with garlic, ginger, curry, and other strong flavored herbs and

spices and is appreciated in many cultures for its property of thickening soups.

Vine spinach is a nutritious vegetable. On a dry weight basis it is in the same elevated category as moringa or chaya. Moringa leaves are about 79% moisture, while basella leaves are 93% moisture. This means that 100 g of fresh moringa will have 21 g of dry matter and 100 g of basella will have only 7. When both are fully dried, basella leaves will have a very similar nutritional profile to moringa leaves, with somewhat less protein and iron but more calcium, vitamin A, vitamin C, and folate. Still the real beauty of basella is that it provides abundant, mild tasting greens through the heat of the summer when few others are available.

Katuk, Sweetleaf Bush, Tropical Asparagus, Chekkurmanis - *Sauropus androgynus*

Katuk is another tropical shrub in the Euphorbia, or poinsettia, family. It is native to the humid forests of southern Asia, perhaps originating in Indonesia. It is a fast growing and nutritious plant that is not well known outside of Southeast Asia. The tender young leaves of the plant are sometimes eaten raw in salads. The flavor is often compared to fresh peas, nuts, or peanuts. Older leaves should always be cooked. The shoots have been marketed as tropical asparagus.

Katuk is usually propagated from seeds but stem cuttings are sometimes available

locally. Stems about 25 cm (10 in) long are rooted in good quality soil and begin to produce roots within a week or so. The plant grows quickly in fertile, well drained soil and is normally pruned to keep it from growing too tall for easy leaf harvest. The stems are relatively weak and katuk that is not pruned back is prone to fall over as it gets tall. Edible leaves are abundant all year round.

Harvesting leaves and shoots stimulates production as long as soil organic matter, fertility, and water are adequate. It does well in partial shade and is often grown in orchards of taller trees or in tightly planted hedge rows. Katuk has few pests, though slugs are sometimes a problem. It is a purely tropical plant and won't tolerate freezing temperatures. It can, however, be grown as an annual in warmer parts of the temperate zone. It can also be grown in a container and brought inside for a short winter.

Katuk leaves are rich in protein for a vegetable and are an excellent source of iron, calcium, beta-carotene and vitamin C. There have been incidents where some people drinking large amounts of raw Katuk juice as part of a weight loss scheme suffered serious lung damage. The component of the katuk juice responsible, and the biochemical mechanism that caused the lung damage, are still not clear. Obviously, it is a sound idea to avoid drinking large amounts of raw katuk juice and to avoid eating large amounts of raw

katuk leaves. However, katuk has been a valuable contributor to the diet of Malaysia, Indonesia, and southern India for centuries and is safe when eaten in moderation.

Okinawa Spinach, *Gynura*, Hung tsoi - *Gynura crepioides*, *Gynura bicolor*

Okinawa spinach is a perennial plant in the huge aster family. It is native to the humid tropics of Southeast Asia, and that is still the region where it is primarily grown and eaten. *Gynura* is an excellent yard plant and is often grown as an edible ornamental due to its striking foliage with green upper sides and purple lower sides. It grows in clumps quickly reaching 1 m (3 ft) in diameter and 1 m (3 ft) in height.

The leaves are nutritious and regrow rapidly, making it an exemplary cut-and-come-again home garden vegetable. Regular pruning stimulates further leaf production. It is almost always propagated by cuttings, which take a week or so to root and four or five weeks to reach harvest size. It prefers well drained soil with plenty of added organic matter. Once established, Okinawa spinach grows fast enough and densely enough to hold its own against weeds. It is bothered little by pests or disease. It will not tolerate a hard frost but it produces edible leaves quickly enough to be a candidate for growing as an annual vegetable in temperate areas with a hot summer, provided that stem cuttings can be secured. It can produce up to 24 tons

per hectare (11 tons/acre) of leaves annually from repeated harvesting.

Once harvested, the quality of the leaves declines rapidly unless refrigerated. Okinawa spinach is sometime eaten raw in salads but it is more often steamed, stir-fried, or added to soups and stews. It has a strong and distinctive flavor often described as piney. It is frequently mixed with milder greens to keep from overwhelming the flavor of prepared dishes.

Brazilian spinach, Samba lettuce, Sissoo spinach - *Alternanthera sissoo*

Brazilian or sissoo spinach is one of the few perennial members of the amaranth or pigweed family. It is native to Brazil, where it is a popular garden vegetable. It is a short, sprawling ground cover that is sometimes used to smother weeds as well as provide greens. Brazilians often eat tender young sissoo leaves raw in salads, while more mature leaves are always cooked to reduce bitterness. It shares many of the attributes and drawbacks of the more familiar amaranths. It is easily established, fast growing, mild flavored and highly nutritious. On the negative side it is prone to insect attack, high in oxalic acid and tends to accumulate nitrates, especially when synthetic fertilizers are used.

Brazilian spinach rarely produces viable seed and so it is propagated from stem cuttings. It is a purely tropical plant and won't tolerate freezing. Like most leaf crops, it grows best in well drained soil

with plenty of organic matter. It grows in a wide range of soil pH and thrives in partial shade. Although it will withstand some drought, a regular supply of soil moisture is important for dependable yields of high quality greens. It is a perfect cut-and-come again vegetable since frequent leaf harvest stimulates continual growth.

It can be grown as an annual in warmer parts of the temperate zone and kept over winter in a container inside a house or in a greenhouse. It is difficult to obtain cuttings of Brazilian spinach in most areas where it is not frequently grown in gardens.

TEMPERATE ZONE PERENNIAL LEAF CROPS

Wolfberry, Chinese Boxthorn, Goji, Matrimony Vine - *Lycium barbarum* and *Lycium chinense*

Lycium barbarum and *Lycium chinense* are two closely related perennial members of the nightshade family, which also includes potatoes, tomatoes, eggplants, and peppers, as well as petunias and tobacco. Both are native to China, where they grow wild and where they have also been cultivated for centuries. With bright green foliage, red or pink flowers, and scarlet berries, wolfberry plants were attractive enough to be imported as ornamentals into Europe. These plants are mentioned for their health-promoting properties in a seventh-century medicinal text. The fruit has recently been added to the growing list of “miracle foods”

by aggressive marketers in the West, who often call it Tibetan or Himalayan Goji berry. The berries are rich in vitamin C and antioxidants, but clinical studies have shown little in the way of miracles.

Wolfberry plants are quite variable in form, ranging up to about 3 m (10 ft) tall, and often rambling from root suckers that quickly generate new plants. Stems can form new plants if they fall over and are in contact with the soil. They are usually propagated from stem cuttings or re-rooting suckers, but they also produce viable seed. Twenty cm (8 in) long pieces of hardwood stem can be started in the spring or fall. Waiting to harvest leaves until the plant is well established will lead to a longer harvest period. Wolfberry is usually replanted every four years.

It is a cold hardy plant but benefits from the protection of heavy mulch in areas with hard winters. It can also be grown as a container plant and brought inside to winter over until milder weather. It will survive in most conditions but produces more greens and fruit if given good drainage and plenty of organic matter. It is somewhat prone to powdery mildew.

Wolfberry is a true multipurpose crop, providing both valuable leafy greens and fruit. Frequent trimming of leaves and stems keeps it orderly and very productive. Wolfberry is often grown as a hedge in China.

In Asia the leaves are most often stripped from the stem (carefully, to avoid thorns) and stir-fried, steamed, or added to soups. Young and tender leaves are occasionally eaten raw in salads, but wolfberry leaves have a somewhat bitter flavor and are generally cooked for a few minutes and used as potherbs. In extensive testing at the Asian Vegetable Research and Development Center in Taiwan, wolfberry had by far the highest content of iron among leaf crops. Given the global impact of iron deficiency anemia, wolfberry leaves may be a crop with an important future.

Good King Henry, Fat Hen, Lincolnshire Asparagus, Mercury - *Chenopodium bonus-henricus*

Good King Henry is a perennial member of the Chenopodium family, which also includes spinach, beets, Swiss chard, quinoa, and lambsquarters. A native of northern Europe, it is one of the more cold hardy leaf crops. It is a multipurpose plant with leaves that are eaten like spinach, edible shoots that are a substitute for asparagus, flower heads like miniature broccolis, and high protein seeds that could replace grains in many dishes. It is normally propagated by seeds that are quite slow germinating. It can also be reproduced from cuttings. It typically is productive for about 5 years but should be harvested sparingly if at all the first year until it becomes well established.

Good King Henry is not particular about soil, though it prefers a slightly alkaline environment. If it has good drainage and ample organic matter it will produce an abundance of nutritious leaves over a long growing season.

The leaves are usually added to soups and stews but the very young leaves are sometimes eaten raw. Like all members of the chenopod family they contain fairly high levels of oxalic acid. People who have had trouble with kidney stones or gout would do well to choose other greens. When the shoots are about 20 cm (8 inches) high they are sometimes steamed like asparagus, after peeling off the outer layer. Like quinoa, Good King Henry seeds have bitter tasting saponins on the seed coat and should be soaked and rinsed well before using.

Stinging Nettles - *Urtica dioica*

The nettles belong to a worldwide family of plants famous for the thousands of tiny stinging hairs or trichomes that defend their nutrient rich leaves from animals. *Urtica dioica*, the most well known of the nettles, has been eaten by humans since at least the Bronze Age. Nettle lore is evenly divided between cursing the stinging hairs and praising the health-giving greens. Nettle leaf and root have been used by herbalists for centuries to treat a wide range of maladies, and more recent scientific investigations are showing that our ancestors were right to respect the irritating weed.

Stinging nettles are usually found growing in clumps in rich moist soil, often along stream banks. The plants can grow up to 2 m (6 ft) high but are more commonly half that tall. They are winter hardy perennials throughout the continental US and one of the earliest greens for making spring tonics. Although often foraged as a wild green, stinging nettles are also cultivated as a market crop, mainly in Europe. It is normally propagated by seeds; a few improved varieties are available from vegetable and herb seed catalogs. Like most leaf crops, they grow best in rich, well drained soil and full sunlight, though they will survive in partial shade. They have few problems with pests and diseases.

Gloves are a good idea when harvesting stinging nettles. The sting disappears completely when the leaves are dried, steamed briefly or added to soups. They are one of the most nutritious of all foods, being rich in protein, iron, calcium, magnesium, vitamin A, and vitamin C. The protein content of nettles leaves is about 7%, qualifying it as a good choice for making leaf concentrate. In addition to being a dynamo of nutrition, stinging nettles are frequently listed as one of the tastiest of all greens.

Wood Nettle (*Laportea canadensis*) is a somewhat smaller plant with less-irritating stinging hairs. It is a common woodland plant throughout much of North America and has a similarly high nutritional value.

Walking Stick Kale, Tree Collards, Jersey Cabbage - *Brassica oleracea longata*, *Brassica oleracea palmifolia*

In the long cool summer days of the British Isles a cabbage of heroic proportions evolved. It was called Jersey cabbage, for the Jersey Islands where it thrived, Walking stick kale for the strong lightweight walking sticks that were made from its stalk, or tree collards, because it could grow up to 6 m (18 ft) tall. It is a perennial member of the cabbage family that can be started from seeds or from cuttings. It typically takes two years to reach a height of 2–3 m (6–10 ft), though can grow up to 3 m (10 ft) tall in just six months. Walking stick kale has been known to provide greens for up to twenty years, if it is well cared for and doesn't experience severe hot or cold weather.

Unless it is being grown as a novelty, it is practical to prune it back to encourage branching at a height that can be reasonably reached without a ladder. At the top of the stem a cap of large grayish-green collard-like leaves form. These can be harvested regularly and will regrow. Leaves are picked from oldest to newest when they are about 15 cm (6 in) long, starting with the lower ones and moving up. This encourages the plant to grow taller. Side shoots will form where the leaf stems have been cut.

Seed is often started indoors about five weeks before the average last frost so that good growth can be made before hot

summer temperatures set in. This plant prefers fertile soil with plenty of nitrogen and a pH that is neutral or even slightly alkaline. It suffers from most of the usual cabbage family pests (cabbage worms, flea beetles, club root) and responds to most of the organic gardening treatments for them. To prevent the plant from falling or blowing over, it should be grown with a strong support pole at least 2 m (6 ft) high.

These giant members of the cabbage family were known as excellent feed for cattle and other livestock, but were sometimes considered a food of the poverty stricken peasantry. The stalks, left to air dry for ten months, were used as a substitute for scarce wood in many applications. But the greatest value of the plants was as a source of protein; calcium; iron; vitamins A, C, and K; and protective antioxidants in the diets of the people of the Jersey Islands. It provides an abundant and reliable source of highly nutritious and tasty greens that can be harvested year round. After a long decline in popularity, it is heartening to see recent renewed interest in this giant perennial leaf crop.

Perennial Onions

Scallion, Welsh Onion

- *Allium fistulosum*

Shallot, Potato Onion, Nest Onion

- *Allium cepa aggregatum*

Egyptian Onion, Walking Onion

- *Allium cepa proliferum*

Ramps - *Allium tricoccum*

Onions are among the most popular vegetables throughout the world. In the west they are best known for the bulbs that form below the ground and make cooks cry on their way to flavoring a thousand different dishes. In most of Asia the leafy tops of onions are more important food crops than are the bulbs. Onion greens are much more nutritious than the bulbs, while imparting a range of similar flavors. Bulb onions have the benefit of being easy to store, but green onions have the offsetting advantage of being relatively simple to grow year round in much of the world. While the green tops of annual bulb onions can certainly be snapped off and used as green onions, most of the vegetables specially grown for green onions are perennials.

There are about 500 different species in the onion family, most of them originating in central Asia. The names of the different types of perennial onions are numerous and confusing and the lines defining the different species and cultivars are often blurred. Most of the many varieties of commonly eaten green onions are

botanically either *Allium fistulosum* or a cross between *A. fistulosum* and *Allium cepa*.

Scallions can be started from seed and are sometimes grown as annuals. At the end of their first year of growth they can be easily divided by gently pulling apart the clumps at their base. Each scallion separated in this way can be transplanted and will form a new clump of green onions. Shallots or potato onions are propagated in a similar way. The main difference is that the base of the shoots is larger than with scallions. They are often allowed to dry in storage and planted almost like small elongated bulb onions in the spring. Egyptian onions propagate by producing clusters of very small bulblets at the top of the scape, or seed shoot. When these become too heavy to support they fall over and take root wherever they have fallen. They are also called walking onions because of this unusual way of “walking” across the garden. Ramps are a perennial relative of leeks that grow wild in many North American woodlands. Their flavor is excellent and they can be cultivated in the garden where they are not available wild. Chives are very small perennial green onions usually considered a culinary herb rather than a vegetable.

Scallions, in particular, are a great crop where space is at a premium. They can be set out as close as every 8 cm (3 in) in each direction in a fertile garden bed, though 20

cm (8 in) spacing is more common. Their frugal use of space makes scallions an excellent container crop as well. They are very hardy, withstanding moderate freezing and returning in the spring.

Any type of onion that is densely planted requires consistent moisture and soil that drains well. Both waterlogging and drought dramatically lower yield. Scallions are heavy feeders and benefit from a side dressing of compost. They are susceptible to weeds because they grow vertically, allowing sunlight to reach the ground around them. Mulch is ideal for controlling weeds as hoeing tends to damage the roots growing near the surface. Given good soil and ample moisture all perennial onions can produce large yields of greens over long periods of time in very small spaces.

Flavorful and nutritious green onion tops can be produced from dozens of types of onions including wild onions and even garlic. They spice up salads when eaten raw and are an excellent addition to soups, sauces, and stir-fries. Dried and finely ground onion leaves can add flavor, nutrition, and color when shaken over popcorn, rice, or any starchy bland foods.

Green onions have been used for at least 4,000 years for food, flavoring, and traditional medicines. They combine the benefits of onions and green leafy vegetables. They are an excellent source of vitamin K and vitamin C, and a good source of vitamin A and folate. Modern science has confirmed

most of the disease fighting properties traditionally attributed to green onions. High levels of antioxidants, especially quercetin, and sulfur compounds are the biochemical forces behind the onions. Green onions have been shown to reduce the risk of stomach cancer and to have a beneficial impact on several respiratory, circulatory, and gastrointestinal disorders.

LEAF VEGETABLES AS FLAVORINGS

Many leaf vegetables have strong flavors. This is probably the biggest reason that they are often rejected by children. On the other hand, good cooks in most cultures seek out foods with intense flavors to create dishes with dynamic and complex tastes. Because spices and natural flavorings tend to be expensive or not available in many locations, growing culinary herbs is an attractive idea for many low-income families. Especially where the diet revolves around a few bland starchy staple foods, such as rice, corn, cassava, taro, plantains, and potatoes, strongly flavored leaf vegetables can help fend off mealtime boredom.

Leaves eaten in relatively large quantities are usually called salad greens when eaten raw and potherbs when cooked. Leave used in smaller amounts for their intense flavors are sometimes referred to as culinary herbs. The lines between salad greens, potherbs, and culinary herbs become blurred when strongly flavored leaf vegetables are eaten in larger quantities. For example, the main ingredient in the classic

Middle Eastern dish tabouli is parsley, an herb that is used in much smaller amounts to add flavor or color in European and Latin American cuisine. One of the few European recipes that calls for more than a pinch of highly flavored leaves is the sublime Italian sauce “pesto Genovese,” that is built around basil. Many African dishes use bitter leaf (*Vernonia amygdalina*) and other strongly flavored leaf vegetables in fairly large quantities.

It is in Asia, however, where leaf vegetables come into their own as both potherbs and essential flavorings. In China and much of Asia, green onions (onion leaves) are eaten in greater quantity than bulb onions. The roasted garlic flavor of the toona tree leaves are also used in quantity. The Japanese people are partial to Shungiku, or garland Chrysanthemum (*Chrysanthemum coronarium*), and Shiso (*Perilla frutescens*), two almost perfumed flavored greens. In India a thick sauce of the slightly maple flavored Methi, or Fenugreek leaves (*Trigonella foenum-graecum*), is commonly served over rice. In the Philippines and Indonesia the harsh leaves of the aptly named bitter gourd are eaten in quantity.

Certainly a part of good nutrition is creating attractive and interestingly flavored food, but can these leaves used as flavoring help resolve any of our pressing nutritional problems? If “the dose makes the poison” as the Swiss botanist Paracelsus

CHART 13–1
TOTAL ORAC (OXYGEN RADICAL ABSORBANCE
CAPACITY) PER 100 GRAM EDIBLE PORTION

Food	Trolox equivalents (TE)		
<i>Leaves used as flavorings</i>			
		Sage, raw	32,004
Basil, dried	61,063	Savory, raw	9,465
Basil, raw	4,805	Tarragon, raw	15,542
Chives, raw	3,365	Thyme, dried	157,380
Coriander (cilantro) leaves, raw	5,141	Thyme, raw	27,426
Dill leaves, raw	4,392	Fruits	
Lemon balm leaves, raw	5,997	Blueberries, raw	4,669
Marjoram, raw	27,297	Goji berry (wolfberry), raw	3,290
Oregano, dried	175,295	Grapes, red, raw	1,837
Oregano, raw	13,970	Pomegranates, raw	4,479
Parsley, dried	73,670	Vegetables	
Parsley, raw	1,301	Broccoli, raw	1,510
Peppermint, raw	13,978	Carrots, raw	697
Rosemary, dried	165,280	Onions, raw	913
Sage, ground	119,929	Spinach, raw	1,513
Data from Nutrient Data Laboratory, Agriculture Research Service, US Department of Agriculture, Oxygen Radical Absorbance Capacity (ORAC) of Selected Foods – May 2010, http://www.ars.usda.gov/SP2UserFiles/Place/12354500/Data/ORAC/ORAC_R2.pdf			

proclaimed in the sixteenth century, then the nutrition is also in the dose. Despite the assertions of health food promoters, very small amounts of foods tend to have minimal impact on our health even if they are indeed very nutritious foods.

Foods rich in micronutrients and antioxidants, because they are used in such small amounts by the body, may be exceptions to this generalization.

For instance, shiso is extremely high in beta-carotene. In Japan it is cooked with ginger and sesame oil in servings large enough to provide substantial vitamin A. Bitter melon (sometimes called balsam pear) leaves are rich in folate and have an extraordinarily beneficial ratio of potassium to sodium. Because it is unusually rich in iron, the parsley in tabouli could be a significant factor in preventing anemia, especially because the lemon juice in the recipe enhances iron absorption.

Antioxidant activity is another area where flavorful leaves or culinary herbs are uncommonly endowed. The most widely used measurement of overall antioxidant activity is the Oxygen Radical Absorption Capacity (ORAC) score. ORAC units are usually measured as Trolox equivalents (TE). Trolox is a synthetic antioxidant that serves as a standard for comparison. The USDA advised us to consume 3,000 to 5,000 units daily, but most estimates suggest an average intake of only about 1,200 units, or only about one third of

the recommended antioxidant intake. Low-income families are especially unlikely to reach the recommended levels because many of the high ORAC foods are expensive.

Chart 13-1 shows the ORAC value of some flavorful leaf crops, along with a few other fruits and vegetables that are considered good antioxidant sources, for comparison.

TWO LEAF VEGETABLES TO AVOID

Poke - *Phytolacca americana*

The leaves of a few plants that were eaten with gusto by our ancestors are now considered too toxic to be eaten in even modest quantities. These include the beloved “poke salit” or poke salad of the American southeast. Immortalized in the song “Polk Salad Annie,” this plant was considered an important spring tonic to stimulate the body after the long winter without fresh foods.

Pokeweed contains the alkaloids phyto-laccatoxin and phytolaccigenin, which are poisonous to mammals. Some enthusiasts continue eating young poke leaves after boiling them three times to reduce the toxin and discarding the water after each boiling. Some of the toxins remain even after this treatment. Eating poke may cause vomiting after two hours, followed by perspiration, spasms, and diarrhea. There have been fatal poisonings from poke. Unless in a famine situation, a leaf vegetable

with this much downside that requires this much preparation before eating is best avoided. There are almost always safer wild greens available wherever poke is eaten.

Comfrey - *Symphytum officinale*

Another leaf vegetable that was formerly widely promoted for its health benefits is comfrey. It is a fast growing perennial herb native to Europe and western Asia. Comfrey leaves have been eaten for over 2,000 years. The plant has been used externally to help heal wounds, sprains, and fractures. It has also been recommended at various times to treat ulcers, gallstones, arthritis, diarrhea, colitis, cough, pneumonia, and cancer.

Unfortunately several studies have shown that comfrey contains chemicals called pyrrolizidine alkaloids which can cause severe liver damage. Animal studies have also shown that these chemicals lead to the development of liver tumors. The United States Food and Drug Administration asked supplement manufacturers to remove comfrey products from the market in 2001 because of its potential to cause liver damage. Germany’s regulatory agency for herbs has approved comfrey to be sold only in preparations that supply no more than 100 micrograms per day if applied to the skin, and no more than one microgram of pyrrolizidine alkaloids if taken by mouth. One microgram is one millionth of a gram and there are 28 grams to an ounce, so these are potent toxins.

It is frequently assumed that a food that has been eaten for a long time by many people must be safe. While this is generally the case, sometimes the negative impact of a cumulative or long term toxin such pyrrolizidine alkaloids will be noticed so long after the food is eaten, that no association is made.