Capturing solar energy as food

Capturing solar energy as electricity

CHAPTER THREE

The Potential and Limitations of Leaf Vegetables

POTENTIAL OF LEAF VEGETABLES TO IMPROVE NUTRITION

One's nutritional status is largely determined by economics and culture. People with very little income spend most of it on food, and they tend to buy the cheapest calories available. Usually this means corn, rice, wheat, cassava, potatoes, plantains, and sugar. Increasingly the cheapest form of these staple foods is not in their crude unprocessed state, but after they have been refined for ease of shipping and marketing. The result is people sitting down to plates of white rice with cassava flour sprinkled over it in Brazil, to white corn meal pap in Swaziland, and to bowls of refined rice in south Asia. They will likely get barely enough calories; have a marginal or slightly inadequate supply of protein; and a decided shortfall of vitamin A, iron, and calcium as well as many other vitamins, minerals, and protective antioxidants.

For these people, green leaves could make a real difference. Why? Because they can be produced cheaply—cheaply enough to be available to even the poorest among us. Over two billion people live on two dollars or less a day. They often spend over half of their income on food. Food prices have been going up rapidly: staple foods like rice and wheat more than doubled in price from 2000 to 2009. You don't need a degree in economics to see the hunger in the math.

Green leaves can serve as a nutritional complement to staple foods at a very low cost. For example, adding 20% dried moringa leaf to white rice will increase its protein content from six percent to ten percent. Adding it to cassava will increase the protein from 1% to 6%. Vitamin A activity in food is most commonly measured in retinol activity equivalents (RAE). Applied to green leaves, we observe that a 100-gram (3½ oz) serving of cassava has the equivalent of one microgram of RAE; white corn meal and white rice have none. Easily grown vine spinach (*Basella alba* and *B. rubra*) leaves each contain 400 micrograms of RAE; kale has 768. Raw broccoli and grape leaves, which are often discarded, have, respectively, 800 and over 1,000 mcg RAE.

Iron deficiency anemia is considered to be the most common nutritional disorder in the world. It prevents the blood from carrying enough oxygen to fully energize bodily functions. Anemic people lack physical, mental, and emotional energy. Their span of attention is shorter and their memory and concentration worse than people with adequate iron. Where do people with minimal income find iron? Not in corn meal, rice, plantains, or cassava. A hundred grams (3½ oz) of each of these foods contains, respectively, 1.1 mg, 0.8 mg, 0.6 mg, and 0.3 mg iron. On the other hand, 100 grams of dried Chinese boxthorn, moringa, parsley, or chaya leaves all have over 20 mg of iron.

Greens can produce the missing iron quickly and cheaply. A study in Taiwan showed that Chinese cabbage produced 13 times more iron than grains in the same space over the same time. The same study showed that the cabbage was 11 times more cost-efficient than chicken as a source of dietary iron.[1]

What about people who aren't in such desperate economic situations? What do leafy greens have to offer them? Leaf vegetables have high nutrient densities. Nutrient density describes the nutritional value of a food relative to its calories. So by eating foods that are low in calorie density but high in nutrient density, one can keep one's weight under control while ensuring good nutrition. Leafy vegetables are good sources of several of the minerals and vitamins sometimes lacking in modern diets as well as fiber and antioxidants that are notoriously lacking in industrialized diets.

POTENTIAL OF LEAF VEGETABLES TO IMPROVE SUSTAINABILITY

There are at least three areas in which greater use of leaf crops could help build sustainability into our food systems.

Increasing the biodiversity of our food supply

Human beings by their nature are highly adaptable omnivores. We can thrive on a wide variety of different foods. This is obviously a huge survival advantage over specialists like koala bears who eat only eucalyptus leaves, or pandas that specialize in bamboo leaves. However, as our population has grown to 6½ billion we have become extremely dependent on fewer than 10 of the roughly 350,000 known flowering plants. Corn, rice, wheat, potatoes, cassava, and soybeans supply the majority of the calories eaten by humans on earth. Stable ecosystems on the other hand are characterized by a large number of species linked together in mutually beneficial webs. Over 1,000 species of plants have leaves that are edible to humans. Using more of them in our food system could widen the base and offer alternative means of meeting our requirements for several key nutrients. Growing a wider range of food plants would spread our risk, offering some protection against catastrophic insect or virus attacks on any of the big six staple crops.

Reducing energy costs of producing, processing, and distributing food

Leafy green vegetables will grow almost anywhere, and with a little help they can be grown year round in all but the harshest conditions. Growing leaf crops closer to where and when we eat them would save a significant amount of energy while providing fresher and more nutritious food. Solar drying of leaf vegetables is another energy saver. Because leaves form in thin sheets they are easy to dry. Simple inexpensive dryers using only the free energy of the sun can easily preserve them for later use.

One of the most important ways that leaf crops could reduce energy use is by substituting them for some of the animal-based food in the Westernized diet. Animal products almost invariably require more energy to produce than vegetable-based foods. Because of this most attempts to cut the energy used in the food system begin by trying to reduce the amount of animal products produced. Techniques exist that can greatly improve the nutritional quality of green leaves. These techniques make it possible to obtain more proteins, vitamins, and minerals with much less reliance on energy-intensive industrial meat production.

Better integration of food crops into ecosystems

Stable or mature ecosystems are complex and largely self-regulating biological communities. They are frugal with the sunlight that powers them and the rain that falls on them and they recycle nutrients efficiently. They have a large number of interdependent species held together in a dynamic balance of competition and cooperation. Sustainable food systems will need

1 The integrated research approach of the Asian Vegetable Research and Development Center (AVRDC) to enhance micronutrient availability; Mubarik Ali and Samson Tsou; Food and Nutrition Bulletin, vol. 21, no. 4 ©2000, The United Nations University

to look and act more like ecosystems than biological factories.

The great variety of plant types that produce edible leaves will be very useful in making a transition to a more ecologically stable food system. Leaf crops can take the forms of twining climbers, annual herbs, perennial shrubs, even trees. Amaranth can be harvested in thirty days; barley and Austrian winter peas can be planted after the first frost. Cowpeas and fenugreek are nitrogen-fixing legumes that can be intercropped with plants that are heavy nitrogen feeders. Watercress and kangkong can be grown in water. Tender tropical leaf crops like soko and basella laugh at heat that sends spinach and lettuce bolting (prematurely producing a seed stalk). Siberian kale shrugs off temperatures down to minus 17 degrees Celsius (or zero degrees Fahrenheit). The atriplex family has several edible leaf members that are among the most salt tolerant of all land plants. Leaf crops are ideal for growing in containers or rooftops where space is at a premium or weight must be kept at a minimum.

Leaf crops display an amazing range of attributes. Many of the best leaf vegetables come from multi-use crops. Onions, garlic, beans, sweet potatoes, wheat, barley, cassava, peas, okra, and pumpkins are among the many plants that produce edible leaves as well as other valuable foods. Once we know the plants and their growth habits we can invariably get more total food by making informed partial leaf harvests.

You can't use 16-row planters or giant harvesting combines to grow food this way, but you can grow it with less oil energy, less soil erosion, and fewer insect and disease problems. Working in an ecologically sustainable way requires maintaining a population of possible solutions, not just producing bumper crops of one or two plants. A thousand leaf crops are a thousand possible solutions.

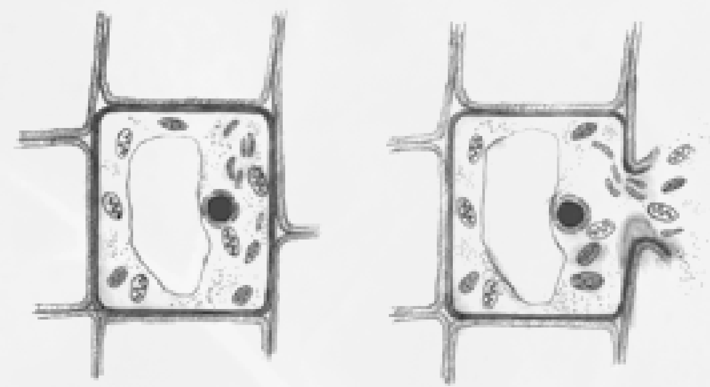
THE LIMITATIONS OF GREEN LEAVES AS FOOD

While many cultures have developed intriguing recipes and processing techniques for using their greens, they still play a relatively unimportant role in the diet. Even this limited role is diminishing as the human population rapidly urbanizes. What is it that is keeping leafy vegetables from taking on more of the responsibility for feeding the world's people? Three things stand out; high fiber content, high moisture content and strong flavors.

High Fiber Content

To do their primary job of photosynthesis green leaves need to expose a large thin surface to sunlight. In order to extend the leaf into the light plants rely on stiff cell walls comprised mainly of cellulose, the fibrous material that makes up most of cotton and paper, and water pressure. When the leaf cells are full of water, they exert pressure on the next cell. When the plant has adequate water the entire leaf is held in place with this water pressure. If the water pressure drops, the leaf quickly wilts and loses it crispness. As a result of this basic structural architecture, when green leaves become food they have a high moisture and fiber content. Water usually makes up between 80–95% of leafy vegetables' weight. Of the remaining dry matter, fiber typically accounts for 10–40%. Their high water and fiber content seriously curtail how much we use leaves as food.

The fiber from the cell walls, especially along the veins of many leaves, can make them difficult to chew and to swallow. This



Cell wall ruptured, nutrients released

Fresh harvested leaves

Wilted leaves

is especially true for young children whose teeth and digestive tract muscles have not yet fully developed. Elderly people also often have dental limitations that affect their ability to eat tough or stringy foods. As the leaf matures the amount and rigidity of the fiber normally increases. Young immature leaves typically have lower fiber content, are easier to chew and are almost uniformly preferred for foods.

The fibrous cell walls impact not only the texture but also the nutritional value of the leaf vegetables. Acting like miniature cardboard boxes, they enclose much of the protein, vitamins, and minerals in the leaf, and make it difficult for our digestive enzymes to reach these nutrients. Even when the cell walls are broken open the fiber tends to entangle with the nutrient rich chloroplasts in green leaves. This makes it more difficult for our bodies to absorb and utilize these valuable nutrients. So while green leaves contain large amounts of important nutrients, they are often in forms that are difficult for us to access. It is this problem of low bioavailability of nutrients, especially of iron and vitamin A, that has led some international nutritionists to discount leaf vegetables as a realistic solution to the anemia and vitamin A deficiency that are rampant in developing countries.

High Moisture Content

The high moisture content of leaf vegetables makes them very perishable. As soon as they are separated from the plant leaves begin wilting, losing both eye appeal and nutritional value. To be shipped, most greens need to be cooled with ice in the field and packed in refrigerated trucks with no delays. Over 90% of leaf vegetables sold in the US are grown in California and Arizona. The cost of shipping them across the country is rising fast with the price of gasoline. It takes more fuel to run the refrigerated trucks than regular trucks, and these costs are always transferred to the customer.

Even with this treatment leafy vegetables have a very short shelf life compared to beans or flour or potato chips or corn flakes or even apples. For retailers, greens are a lot of trouble. If they don't sell within a couple of days they start looking like limp dishrags and someone must assume the loss. This is why you won't find greens in convenience stores. These are stores that have become popular primarily in urbanized parts of the world that have taken the most popular, most profitable and least labor-demanding products from grocery stores. They make a growing percentage of the total retail food business profits with this simple scheme, and there is no room for leafy vegetables in it.

Most people in the world don't have refrigerators in their homes. Vendors selling greens to people without refrigerators normally have one day to do so, and the people buying greens need to cook them the day of purchase. As more mothers throughout the world look for employment, convenience of preparing meals grows in importance and the short shelf life of greens is decidedly inconvenient.

Strong Flavors

The third limitation of green leaves as a source of food comes from bitter or strongly-flavored compounds. Because of the vast number of plant species and the dynamic biochemical environment of green leaves, there are many thousands of chemical compounds in green leaves. Not all are delicious and not all are helpful to the human body. There is a good reason that plants often have delicious fruit but harsh-tasting leaves. Since plants can't move, they often enlist the aid of mobile animals to distribute their seed. Packaging the seed within a tempting fruit convinces the animal to eat the seed whole without damaging it. Pectin and other soluble fibers in the fruit also encourage the animal to deposit the seed along with some manure to fertilize the new plant.

Plants do not have a similar motive to make delicious leaves. Anticipating a certain amount of feeding on them, they universally can produce more leaves than they need to survive, but they also usually have some strategy to reduce or control animals feeding on their leaves. Plants often use harsh-tasting and bitter compounds to accomplish this end. Some are binary weapons, as with members of the onion family. The action of something eating or cutting the onion plant tissue brings together two compounds that are stored slightly apart and releases a dilute mist of sulfuric acid. These various plant defense mechanisms present a challenge to human consumption.

The next section of this book will look at some of the ways that these limitations can be overcome and both the nutritional and ecological potential of green leafy vegetables can be realized.

COMMON & SCIENTIFIC NAMES

Plants have common names as well as scientific or botanical names. Most of the time the common name suffices. Sometimes, however, we need more clarity between two similar plants or between two plants with similar common names. Additionally, common names are in local languages so the common name of a plant in Indonesia is probably useless in Spain.

The universal system science uses for naming species is called binominal—or binary—nomenclature. The binomial system originated with the Swedish botanist Carl Linnaeus (1707–78), who ambitiously attempted to describe the entire natural world. To name every organism, he used a seven-category system that places living beings in progressively smaller groupings: kingdom, phylum, class, order, family, genus, and species.

Generally only the Latin genus and species names are used, giving every species a two-word name. The first is always capitalized and refers to the genus of the plant or animal. The second name is not capitalized and refers to the species within the genus. Scientific names are usually italicized.

While it may seem overly formal, the binomial system comes in handy when discussing leaf crops from around the globe, even when using the same language. For example, the common name pigweed may refer to *Amaranthus retroflexus* or any number of other amaranth species, or to lambsquarters (*Chenopodium album*). Common names like spinach or cabbage are used to refer to all sorts of plants including New Zealand spinach, water spinach, and Malabar spinach. Cabbage is even trickier, with Chinese cabbage, deer cabbage, dog cabbage, skunk cabbage, Maori cabbage, poor man's cabbage, and others. Not all of them make decent coleslaw.

Sometimes a group, subspecies, variety, or cultivar name follows the species name. Varieties are subdivisions of species. They refer to naturally occurring changes or mutations which create a distinctive appearance, such as variations in flower color or growing habits. Cultivars refer to varieties which, although they may occur naturally, can only be reproduced by human intervention. Hybrids refer to new varieties of plants, which were created by humans through cross pollination of separate varieties. When *spp.* follows a genus name, such as *Amaranthus spp.*, it is referring to more than one species within that genus.

Common cabbage is *Brassica oleracea capitata*, while kale and collards are *Brassica oleracea acephala*. They are varieties of the same species: *capitata,* "with head," and *acephala,* "without head." If your Latin is rusty or worse you can still sometimes derive information from the scientific names. Berseem or Egyptian clover is *Trifolium alexandrinum*. *Trifolium* means three-leafed and *alexandrinum* refers to the Egyptian city of Alexandria. Occasionally botanical names, like *Calopogonium mucunoides* or *Crotolaria spectabulis*, dance poetically off the tongue. With more people traveling around the world and sharing plants and foods with each other, the universal language of binomial nomenclature will become ever more useful. A short list of some botanically helpful Latin words can be found in Appendix 3.