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BLOSSOMING TREASURES OF BIODIVERSITY:
 30. Miracle Fruit – Making life sweeter

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Everyone detests at least some foods. Would you accept an invitation to a party to sample foods that normally taste awful? But imagine that the star attraction of the party is an exotic fruit that makes the sourest and the most bitter of substances taste wonderfully sweet. Your first reaction might be, "it must be dangerous, and is probably illegal". To find out, read on.

THE PLANT

Miracle Fruit (*Synsepalum dulcificum*) is a shrub or small tree growing to a height of 5.5 m (18 feet) in its native habitat, but usually no more than 1.5 m (5 feet) elsewhere.

It typically develops an oval or pyramidal shape. The leaves are evergreen, deep green, papery-leathery, elongated, and arranged in a spire-like fashion. Forms of the plant with rather hairy leaves and forms with smooth



Figure 1. Miracle Fruit (*Synsepalum dulcificum*). Source: Engler, H.G.A. (Editor and Contributor). 1904. Monographien afrikanischer Pflanzen-Familien und -Gattungen. Wilhelm Engelmann, Leipzig, Germany. Vol. 8, plate 7.

leaves have been reported. The flowers are brownish-white and small, generally about 1 cm (0.4 inch) long. A single large plant can produce hundreds of berries. The fruits are dull green when immature, ripening to bright red. They are ellipsoid, approximately 2–3 cm (0.8–1.2 inches) long. A single seed surrounded by thin, soft pulp is present in the olive-like fruit.

GEOGRAPHY AND ECOLOGY

Miracle Fruit is native to the hot, humid, tropical lowlands of West Africa, including parts of Ghana, Benin, Nigeria, Cameroon, Central African Republic, The Democratic Republic of the Congo (formerly Zaire), and Gabon. The species is now cultivated in tropical regions of Asia, South America, and Florida. The plant requires a frost-free climate, although mature plants can survive light frost. In its native area, Miracle Fruit is often grown on farms and near dwellings. The species can be grown outdoors as far north as southern Florida, and as a container plant in more northerly locations. In West Africa, miracle fruit produces two crops after the rainy season, but generally the plants tend to be in flower and fruit sporadically throughout the year. Berries may be produced in as little as 2 years, but the plants are slow-growing. The plants need an acidic soil (a desirable pH range is 4.5–5.8) and, if grown in a pot, a water soluble, acidic fertilizer is recommended. The plants prefer a humid environment and a well-drained soil with some organic content. In their native area they do best with some shade, but when cultivated in more northern locations they are best provided with full sunlight. Because of the wide interest in Miracle Fruit in recent years, plants are available from nurseries, especially in warm areas, and seeds are obtainable from web-based suppliers. As with most tropical plants, the seeds are “recalcitrant” (they cannot be preserved in a viable state at low temperatures). Seeds should be germinated within a few weeks, and the germination rate is often low (about 25%).

WHY MIRACLE FRUIT IS MIRACULOUS

The phrases “miracle fruit” and “miracle berry” have been employed commercially to exaggerate the medicinal value of several fruits, including blackberry, blueberry, noni, papaya, and raspberry. (See #20 in this series, which discusses “Miracle Tree”, an unrelated species.) However, these names have been used in the last several years primarily for *Synsepalum dulcificum* (once known as *Richardella dulcifica*). In 1725 explorer Chevalier de Marchais visited West Africa and reported that local tribes chewed the berries of a shrub before meals. The name “Miraculous Berry” was used by W.F. Daniell in 1852, who noted that European travellers and traders had coined the name to describe the extraordinary sweetening ability of the fruit. This name is still widely used, but “Miracle Fruit” is adopted here since it is also widely employed, and is shorter. The species is one of the most interesting of plants, known for its curious sweetening properties. *Dulcificum* in the scientific name *S. dulcificum* is based



Figure 2. Approximate distribution of Miracle Fruit (*Synsepalum dulcificum*). The species occurs primarily in lowland humid tropical areas within the region indicated.

on the Latin *dulce*, sweet + *icum*, a suffix indicating exceptional development of this characteristic. The berries contain a substance called miraculin, which is not sweet, but changes the flavour of acid foods such as lemon and rhubarb into a delicious sweetness, and even removes the bad taste of vinegar. One-thousandth of a gram (about 0.000035 ounce) of miraculin is sufficient to make a lemon (without sugar) taste like lemonade.

Miraculin is a “glycoprotein” (a protein molecule with a carbohydrate component), composed of 191 amino acids and some sugar chains. There has been scientific investigation of why it changes taste perception, but a clear explanation is not yet available. It is widely thought that there is a lock-and-key mechanism between taste receptors (primarily on the tongue) and flavour molecules (the shapes of which fit into complementary openings in the receptors). It has been hypothesized that miraculin binds to the tongue’s taste buds, distorting the shape of sweetness receptors, so that molecules that are normally sour (particularly acids) or bitter are temporarily perceived as sweet.

Synsepalum dulcificum is one of about three dozen species of *Synsepalum*, and there have been reports that other species (notably “Giant Miracle Fruit”, *S. subcordatum*) also have fruit with the same taste-altering effect, but this has not been verified.



Figures 3-4. 3, Rodrigo Fernandez, Costa Rica's main grower of Miracle Fruit, standing next to a Miracle Fruit tree somewhat more than 20 years old. Photo courtesy of CostaRicaPhotos.com. 4, Branch of Miracle Fruit (*Synsepalum dulcificum*) with fruits and flowers. Photo courtesy of Logee's Tropical Plants.

ECONOMIC IMPORTANCE

Miracle Fruit has not yet achieved importance as a crop. However, the striking effect of the fruits on taste perception has made the plant a highly desired curiosity that can be cultivated as a house plant in northern areas, and a garden

plant in hot climates. To date, the use of Miracle Fruit as a food plant has been significantly developed only in Japan.

An ambitious attempt to market Miracle Fruit chewing gum and other products in the United States ended in 1974 when the Food and Drug Administration effectively banned the sale of all Miracle Fruit products. Miracle Fruit was classified as a "food additive", making it necessary to provide very expensive research to satisfy regulatory requirements. Nevertheless, Miracle Fruit products are advertised and offered from international sources on the Internet. At present, Miracle Fruit can be sold as a "dietary supplement" in the U.S. Fruits currently sell for 2 to 3 dollars (U.S.) apiece, seeds for about the same price, seedlings (a few inches high) for about \$20.00, and established potted plants for much more. Freeze-dried extracts sell for 1 to 3 dollars/tablet.

USES

Although miracle fruit is not itself sweet (it is relatively tasteless, but has been compared to a bitter cranberry), when a single fruit is eaten and the fleshy pulp is allowed to coat the taste buds of the tongue and inside of the mouth, the effect is extraordinary. Within a few minutes one can eat a slice of lemon or lime without wincing. The attractive aroma and inherent sweetness of the citrus remain but the sourness is almost completely removed. The taste of already sweet foods can become cloyingly sweet (however, the taste of unsweetened foods is often not changed). The sensory reprogramming often remains strong for 30 minutes and detectable for 2 hours (the effect lasts longer with cold foods). While fresh berries are very potent, damaged fruit or crude extracts quickly become denatured. However, chemists have learned how to stabilize the extracted miraculin. Miraculin is a protein, and becomes denatured with heat, so Miracle Fruit cannot be used in cooking. The berries last only a few days after they are harvested, and should be consumed soon after picking. Refrigeration or freezing does prolong the life of miracle fruits for a short period, but even if stored in the refrigerator for a day or so, they often lose their effectiveness. Freeze-dried extracts (claimed to last about a year) have been widely marketed in tablets via the internet (but not legally in many countries).

Ghanaians and other West Africans use Miracle Fruit to improve the flavour of maize dishes and beverages such as palm wine or tea; to obscure the sour taste of various food substances, such as lemon, lime, and grapefruit; and even to improve the taste of stale food. Miracle Fruit has been consumed in Africa to counteract the very bitter taste of quinine (used against malaria). The small twigs have been used as "chew sticks", reminiscent of toothbrushes.

In Africa, native people have used Miracle Fruit to alleviate malaria, fever, piles, coughs, and diabetes. Miracle Fruit has been touted by some as useful for modern health care: in diabetic and weight-control diets (as a sugar substitute, by virtue of the ability to make non-sugary, low-calorie foods taste sweet), and in cancer and other therapies where medical treatments have the effect of reducing the taste

appeal of foods (chemotherapy, for example, may produce an unpleasant, metallic aftertaste). Miracle Fruit is used to some extent in Japan in treating diabetes and obesity, but authorized medical use of Miracle Fruit is generally not supported. There has been some research indicating that miraculin affects sensitivity to insulin, suggesting it may in fact be useful for diabetes.

Miracle fruits are a marvellous topic of conversation. They have become the subject of “taste-tripping parties” (sometimes called “flavour-tripping parties”), the guests consuming the fruits and testing the effects on the taste of various foods, such as Brussels sprouts, broccoli, sauerkraut, martinis, oysters, limes, grapefruit juice, and pineapple juice. Under the influence of Miracle Fruit, many familiar foods acquire quite different tastes, for examples: beer is said to taste like a chocolate milkshake, lemons like sweet lemonade, goat cheese like cheesecake, vinegar like apple juice, and Tabasco sauce like doughnut glaze. Banana, however, is said to still taste like banana.

TOXICITY

While the consumption of Miracle Fruit makes very acidic foods like lemons and vinegar palatable, such foods can be damaging to the mouth and alimentary canal. The acidity of the fruits is not changed, merely the perception of taste, and those who consume acid fruit to excess may develop ulcers of the mouth and alimentary canal. Common sense dictates that such foods should be sampled only in very small amounts. To date, there has not been significant concern about negative health effects resulting from consumption of Miracle Fruit.

“Biopiracy”, “Fair Trade”, and the African Experience

“Biopiracy” (a contraction of biological + piracy) is a somewhat imprecise term that generally refers to the commercial exploitation of novel resources and/or traditional knowledge about the resources of a given country, by foreigners without permission of that country. There has been resentment, particularly in undeveloped countries, when foreign companies have usurped the unique animals, plants, or techniques for utilization of species to develop profitable pharmaceuticals, crop varieties, and patented industrial products. Many countries are now developing legislation to prevent the removal of such resources and techniques without authorization and/or without sharing the profits with the countries from which the species originated or with the indigenous peoples who developed cultural knowledge of how to use the species. “Bioprospecting”, the search for utilizable resources and indigenous knowledge, is now widely practiced by pharmaceutical companies, particularly in tropical countries because they are “megabiodiverse”, i.e. populated by of the order of ten times as many species as temperate region countries. “Fair trade” has become the established phrase for a social movement assisting developing countries to export goods to developed countries. The goods in question are then competitively priced or sold at a slightly

higher price than obtained normally. The consumer has the satisfaction of knowing that marginalized producers and workers are assisted in establishing viable and self-sufficient, small-scale business operations in which they have vested interests, and that a high-quality product has been produced in an environmentally acceptable, sustainable fashion. Both biopiracy and fair trade highlight social concerns about providing adequate compensation to relatively impoverished people in developing countries.



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Figures 5-6. 5, Longitudinally split fruit of Miracle Fruit, showing large seed inside. 6, Miracle fruits. Photos courtesy of CostaRicaPhotos.com.

Biopiracy is a critical environmental concern for exotic economically important plants. Climate change requires that new varieties of crops be available that can withstand changing local climates that become hotter, colder, drier, or wetter, and soils that become eroded or more saline. Wild species and land races (relatively primitive cultivated forms maintained in a region by local farmers) can be essential for breeding new crops, and therefore their use is of great importance to undeveloped countries.

Why should those concerned with Biodiversity care about the above issues? In much of the Third World, small “subsistence” farms are still the norm. While subsistence agriculture is much less efficient than factory farming, it is much more compatible with the environment. In tropical and subtropical countries, which have many more species than temperate regions, subsistence and small-scale farms assist in the survival of threatened biodiversity, a key issue facing the world. A related matter is the supply of land races”; many of these would disappear with the elimination of the farms. Small, rural farms tend to use fewer biocides, and make more use of natural fertilizers (especially manure). These farming traditions are of great value to the health of the planet and its wild species.



Figure 7. Table set for a “taste-tripping party”, a phrase that has become popular in the early 21st century. It denotes parties in which guests consume miracle fruits or miracle fruit extracts, and afterwards sample a variety of foods to experience how their taste perceptions have changed. In front are miracle fruits and capsules with extracts. At the back are several foods usually present to examine the change in taste perceptions. Prepared by B. Brookes.

In 1992 the United Nations “Earth Summit” conference in Rio de Janeiro, Brazil, led to the “Convention on Biological Diversity” which was signed by 150 countries, representing over 90% of United Nations member countries; the agreement came into effect in 1993 and has since been ratified by more than 192 countries. Article 15 of the convention deals with access to genetic resources, providing legal rights to countries to limit access to their plant and animal species, and to obligate foreign parties to enter into agreements for usage. Unfortunately there are often no consequences for those who simply usurp the resources of Global South nations. To date, there has been virtually no recognition of the fact that Miracle Fruit is an African contribution to the world, and that its future commercialization should involve a measure of practical compensation. In the case of Miracle Fruit, it would be appropriate for the African nations where this species is indigenous to receive support for scientific and conservation evaluation of this unique plant.

PRIORITIES AND PROSPECTS

Very little biological information has been published on *Synsepalum dulcificum*, with only sparse data on distribution and ecology. The extent of genetic variation has not been well documented, and the need for conservation measures has not been evaluated. Hopefully now that Miracle Fruit has achieved sudden prominence, basic research on the species will be carried out.

Miracle Fruit has been described as “the most fashionable fad among the Foodie Set”. The problem with fads is that they end, and the long-term economic development of Miracle Fruit depends on development of stable dietary and medicinal uses. The taste-altering properties of Miracle Fruit may be useful for (1) making low-calorie food attractive, and so helping to reduce the current obesity epidemic; and (2) making nutritional food more attractive for patients with dietary restrictions or lowered appetite.

Stevia (*Stevia rebaudiana*; see #1 in this series), another non-calorific, sweetening plant, provides an instructive parallel. It also has been permitted as a “dietary supplement” or herbal product in many Western countries, but prohibited from use in food products. However, certain extracts from Stevia have recently been authorized for commercial use in the United States, and the same will likely occur in most countries where commercial use has also been forbidden in foods. Stevia is on the verge of an explosion of use in low-calorie soft drinks and other products. A similar establishment that Miracle Fruit is safe enough to be used commercially is probably necessary before the plant will achieve a much greater degree of usage.

BELIEVE IT OR NOT

- Like Miracle Fruit, Globe Artichoke (*Cynara scolymus*) tends to reduce sensitivity to sour taste.
- West Africa has two additional species, noted for their taste-altering proteins found in the fruits. One of these is *Thaumatococcus daniellii*, a herbaceous perennial

of Sierra Leone and Guinea; it is also called Miracle Fruit or Miracle Berry, names that are most commonly applied to *Synsepalum dulcificum*. Katemfe Fruit is a preferable name. Proteins (primarily thaumatin) extracted from its fruit are 2000 to 3000 times sweeter than sugar. Thaumatin has passed extensive safety testing, but the technology for using it in industry has not yet been sufficiently advanced to make it a common food additive. Thaumatin, marketed as Talin® by the Talin Food Company, Merseyside, England, is used today for some limited flavour-enhancing applications.

- The other species of West Africa noted for its taste-altering protein is Serendipity Berry, *Dioscoreophyllum cumminsii*, an interesting plant from West Africa, the fruit of which produces an intensely sweet protein, monellin. This species is grown to some extent in the United States. Natural monellin has not been mass marketed to the food industry.
- *Gymnea sylvestre* (Indian Vine) of Eurasia is still another plant with taste-altering proteins, and confusingly it too is called Miracle Fruit. Like *Synsepalum dulcificum*, its action belongs to the “weird but true” category: it inhibits sweetness, so it is possible to suppress the sweet taste of sugar. While reducing sweetness seems hardly desirable, the ability to taste bitterness is also decreased. Jujube (the fruit of *Ziziphus jujuba*) also temporarily reduces sweet sensitivity.
- As many cooks know, salt in low concentrations enhances the sweetness of sugar. (For many people, salted grapefruit tastes sweeter; try it!) Monosodium glutamate is another well-known non-botanical substance that has the ability to enhance the overall flavour of foods.
- Lettuce has been genetically engineering to produce miraculin (reported in Sun *et al.* 2006); two lettuce leaves produced as much as did one miracle berry. Tomato plants have also been engineered to produce miraculin (reported in Sun *et al.* 2007).

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Figure 8. Miracle Fruit (*Synsepalum dulcificum*) grown as a houseplant. Photo courtesy of Logee’s Tropical Plants.

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