Reading 19
Beverage Crops

Even stronger than the need to satisfy hunger is the need to satisfy thirst. Water has always been and will continue to be the prime thirst-quencher. But since the beginning of civilization, inquiring people have sought additives for water that might make it more tasty and zestful, or have turned to various juices and fermentations for their enjoyment as well as to satisfy their thirst.

The earliest "beverage" was probably juice sucked or squeezed from fruit. What with spores of wild yeast blowing everywhere about, it was only a small step further to the discovery that natural fermentation could convert these sweet juices into wines. Nor would it take a great deal of insight to discover that hard, dry grains, which must have been difficult and unpleasant to consume under primitive cooking conditions, could be softened by soaking, and that the resulting liquor would ferment to a pleasant and nutritious beer. (Sumerian tablets more than 5000 years old describe in detail the making of several varieties of beer.) These are still the basic techniques by which people make their alcoholic beverages, the products of fermentation; wines and beers are among the oldest and most cherished of beverages.

Unfermented fruit juices, of course, contain no alcohol. Modern "soft drinks" are, essentially, synthetic fruit juices, compounded of sugar, fruit acids, and other flavorings. But more universally utilized than these are coffee and tea, in which tasteful substances (including stimulating caffeine and related alkaloids) are diffused from plant parts steeped in water. Cocoa, or chocolate, is perhaps consumed less as a beverage these days than it is as chocolate candy, But in its ancestral American homeland, it was highly esteemed as a ceremonial beverage, and it is still much used in hot chocolate or chocolate sodas.

Almost any sugary or starchy substance can be fermented. Primitive tribes in various parts of the world have long used locally available substances for fermentation to alcoholic beverages—the potato in the Andes (for *chicha*), cassava in the tropical lowlands (manioc beers), palm toddy in the Eastern tropics, and various obscure plant materials "secretly" chosen by the shaman for ceremonial purposes. Some of these products are hallucinatory and even semi-poisonous. A few secondary beverage plants can be listed, but coffee, tea, chocolate, beers, and wines must serve here as examples of beverages derived from plant sources.

Fig. 1. Woman stripping coffee berries in the highlands of Kenya. [Photograph by Per Gunvall, courtesy World Bank.]

Coffee, *Coffea arabica* (Rubiaceae)

Unlike most of the crop species discussed in this chapter, coffee (Fig. 1) is a relatively recent domesticate, having become popular as a beverage only since the eighteenth century (although the berry may have served as a stimulant and "medicinal" much earlier in tribal cultures of the Near East). So quickly and widely has coffee become popular that today it ranks among the leading international agricultural commodities. Total world production of dry "beans" reaches about 4 million metric

tons annually, nearly one fourth of which comes from Brazil. Colombia is the next most important coffee-raising country, followed by Mexico, Central America, Indonesia, and several African nations (principally Ivory Coast, Uganda, and Ethiopia).

The genus *Coffea* is a large one, numbering about 40 species. Only two of these species have attained commercial importance for the fruit or berry: *C. arabica* (accounting for about 75% of the coffee crop), and caffeine rich *C. canephora* ("robusta" coffee, mainly produced in Africa, and especially suitable for making "instant coffees). The species *C. arabica* is tetraploid with 44 chromosomes and is self-compatible; all other species are diploid with 22 chromosomes and are apparently self-incompatible,

Recent investigations leave little doubt that *C. arabica* is native to and still grows wild in the mountainous sections of Ethiopia. It is difficult to tell the escapes from indigenous plants, so little has domestication altered the species. Perhaps during the Middle Ages the first coffee plants were brought from Ethiopia to Yemen, where cultivation may have begun, and these yielded the planting stock taken to Java by the Dutch in the seventeenth century and to the New World early in the eighteenth century. Brazil gained highly restricted live coffee seeds when serving in 1727 as arbitrator of the boundary dispute between French Guiana and Dutch Guiana. Plantings were first made in lower Amazonia, but by the end of the century bad extended to southern Brazil, the center of production today. Most Brazilian coffee is from the 'Mundo Novo' cultivar, said to be a hybrid between *C. arabica* var. *arabica* and a mutant from Réunion Island, *C. arabica* var. *bourbon*.

A serious leaf rust disease, caused by the fungus *Hemileia*, has accompanied coffee wherever it is grown, arid native breeding stock capable of resisting the disease has been sought in the Ethiopian homeland. The rust does not seem too troublesome on the robusta coffees in Africa, provided the trees grow in the shade of an overstory of such species as *Albizzia*. Because coffee has attained such great commercial importance within the last century, a number of elite clones have been selected in various parts of the world for vigor, yield, and degrees of resistance against disease.

Coffee thrives best in a rainforest habitat at moderate elevations. The southwestern Ethiopian homeland has an average annual rainfall of nearly 160 centimeters (63 inches), with the months from April to September having the heaviest rainfall. Coffee cannot stand freezing, and it performs best where seasonal temperature variation is small and the average temperature is about 20°C (68°F), It grows best on deep soils, which in its Native African homeland are generally volcanic. When first introduced into Brazil it was grown on low valley land, and was only later found to prosper far better at the higher elevations in Saõ Paulo, on deep soils rich in iron and potassium.

In Africa the coffee trees are often grown as dooryard plants for local use. But a number of large coffee plantations have been established, in which crop production is more efficient. Yields have gradually been increased to nearly 700 kilograms per hectare (about 620 pounds per acre), but under experimental conditions yields nearly twice as high have been obtained. Coffee yields are greatly increased by mulching (usually alternate rows are mulched each year). In Africa, coffee plants are usually started from seed in nurseries and transplanted to the field. In Brazil, direct field planting is common, with 3 or 4 seeds sown to a hole to provide several "stems." Recommended spacing for mature multiple stemmed trees is about 3 meters (10 feet). In Africa, the tendency is to shade the plantation (thus reducing bearing, which would otherwise have to be controlled by pruning, and also helping to inhibit rust); in Brazil, plantings are generally in the open. In most tropical lands, weeds are controlled by hand and fertilization is limited. The desirable flavor in coffee seems to result more from the location in which the coffee is grown than the kind or amount of care. Colombian, Blue Mountain Jamaican, and highland Central American coffees are usually

considered superior to African coffees, even though the same cultivars may be planted.

Coffee berries are harvested by hand. In much of Africa and the Near East "dry" harvest is practiced: individual berries are dried in the open long enough to prevent deterioration of the pericarp. At a later time the hard seeds, commonly called beans, are separated mechanically from the pulp, often by special mobile machines circulated from village to village. "Wet" processing is more common in the Americas, the berries first being floated to separate the defective berries from the good ones. The good berries settle to the bottom of the flotation tanks, and pulping machines remove most of the fleshy outer parts. The remaining fragments of pulp are fermented for approximately a day, and the beans are then washed again. The beans are then dried in open paved areas, either on mats or in trays, and polished in special mills. After the beans have been polished they are ready for roasting and grinding. They are about 14% protein, 10–13% oils (including volatile caffeol), and 1.5% caffeine.

The roasting process develops the coffee aroma; the intensity of roast varies from location to location according to the preference of the market. Roasted and ground coffee gradually loses its flavor, and eventually turns rancid, so that "fresh roasted" coffees have particular appeal to the connoisseur. When the ground coffee bean is steeped in hot water, it loses about 25% of its weight as soluble constituents, including caffeine, the stimulant for which coffee is noted. To varying degrees, caffeine relieves fatigue and promotes a feeling of well being, hence the modern "coffee break."

The coffee industry has been beset by cycles of glut and scarcity. Most scarcities have been caused by serious freezes in the chief Brazilian producing regions, such as the one in July 1975; freezes may kill all above ground parts and necessitate a three or four year recovery period for the new sprouts to mature. This can have serious consequences on prices and can mean economic hardship for countries like Brazil, which depend upon coffee for a large share of their foreign exchange. Encouraged by high coffee prices, growers often make extensive plantings that in a few years oversupply the market and depress the price. Brazil has attempted to regulate production by destroying huge surpluses of coffee from time to time or by subsidizing removal of coffee trees. With most of the good coffee land in Brazil now already planted, overproduction may not be so voluminous as in the past; but there are still ample opportunities for increasing coffee production in Africa and the Far East.

Tea, *Camellia sinensis* (Theaceae)

Tea (Fig. 2), like coffee, is a beverage prized for the stimulating effects of the caffeine it contains. About half the people of the world drink it regularly. Tea is made from young leaves of the tea plant, a tropical broadleafed evergreen that may reach a height of 12 meters (40 feet) if not pruned. It grows best in equable, moist environments where the rainfall is at least 150 centimeters (about 59 inches) annually and the temperature varies from 21° to 32°C (70° to 90°F) The best tea growing locations are Assam (northeastern India) and Sri Lanka, which together account for half of the world produc-

Fig. 2. Women picking tea leaves from an unshaded planting in Kenya. [Courtesy World Bank.]

tion. Other important tea producing countries are China, Japan, Indonesia, and Kenya. World production comes to nearly 2 million metric tons annually.

The exact origin of the tea plant is unknown, but the art of growing tea has been practiced in China for 4000 years, and presumably the ancestral tea plants originated there. Tea drinking was not prevalent in Europe and England (where perhaps it is now most common) until the Dutch, and eventually the English East India Company, initiated the tea trade during the 1600s. How important it became as an item of international trade is known to every American school child who has studied about the "Boston Tea Party" and the American Revolution. Tea grows well in the United States, too, some commercial plantings having been made in South Carolina, but labor costs there compared with those in the Orient have not been conducive to the development of a domestic tea industry.

Tea plants are usually started in nurseries as seedlings and then transplanted to the plantation fields. Clonal selections are increasingly being propagated vegetatively. In Sri Lanka, average yields of 895 kilograms per hectare (nearly 800 pounds per acre) are said to increase to 1680 kilograms per hectare (nearly 1500 pounds per acre) where improved cultivars are planted. Tea seeds don't preserve well, and after ripening in October and November they are usually sown immediately. Fields are generally planted 1.25 meters (about 4 feet) apart in locations with ample drainage. Taller trees are sometimes maintained over the plantings for shade (shade conserves moisture to about two thirds that needed in unshaded plantings, and the trees contribute nutritive litter to the soil). The tea plants are top pruned on about a three year cycle to give the plants a low, spreading structure that facilitates leaf picking. The tea plant is adapted to acid soils. It is a "heavy feeder," and, in the normal course of harvesting, 55 kilograms or more of nitrogen is lost per hectare (about 50 pounds per acre). For good production, nitrogen and other nutrients must be restored through mulches, shade tree droppings, manures, and fertilizers. Foliar sprays of urea are often employed, sometimes containing trace elements (especially zinc). Weeds have generally been controlled by hand cultivation, but nowadays herbicides (such as paraquat) are being more and more used. Insecticide application is carefully regulated to avoid affecting the salability of the tea leaves.

Fig. 3. Close-up of tea picking in Indonesia. [Courtesy International Development Association.]

Women circulating through the plantation pluck the leaves by hand (Fig. 3), removing the terminal bud and the two or three leaves immediately below it. A tea bush generally yields nearly 1 kilogram (about 2 pounds) of plucked green shoots per year. The basketfuls of green leaves are brought to a receiving station and subjected to a "withering" (fermentation) that develops taste and aroma. Leaves rich in tannin are considered superior. The withered leaves are rolled to rupture the cells, freeing juices and enzymes that play a part in further fermentation, for which the leaves are spread in moist rooms at a temperature of 26–27°C (79–81°F) for a few hours. Here the brown color and pleasing aroma develop, after which the leaves are dried by warm air until their moisture content is reduced to about 3% and the leaf turns black. Or-

ange Pekoe is a tea of this type, highly esteemed in the western world. Green tea may be preferred locally, but it is a minor export item. Green tea is not withered.

As with the coffee berry, the quality of the tea leaves varies with the area of production (and also with the care taken in its cultivation and processing). Expert tea tasters can almost pinpoint the location from which a sample comes. Obviously much hand labor is involved in tea growing, and the industry remains largely confined to countries with an abundant source of inexpensive labor. In China and throughout Southeast Asia, isolated dooryard trees yield appreciable tea for home consumption. On the large tea plantations, waste leaf and dust fragments serve as a source of commercial caffeine. Tea leaf ready for marketing contains up to 45% soluble materials, including dextrins, pectins, and essential oils as well as 1.5–5.0% caffeine (theine). Tea accumulates several parts per million of fluorine, an element with a reputation for preventing dental caries.

Cacao, *Theobroma cacao* (Sterculiaceae)

Cacao (Fig. 4), the source of cocoa and chocolate, had already been domesticated when the first Europeans reached the New World. There is speculation that the species may be native to the South American lowlands just east of the Andes, but certainly it was well known (and most famed) as the prized *xocolatl* of Montezuma and his Aztec empire of Mexico. Cacao was soon introduced by the Portuguese into Africa, chief seat of modern-day production, which each year totals about 1.5 million metric tons of cacao beans worldwide. About one fourth of the world production comes from tiny Ghana, and one-sixth each from Nigeria, Ivory Coast, and Brazil.

The cultivated cacaos have been divided into three groups: the Criollo (with the finest flavor), the Forastero (the South American cacaos that were introduced into Africa and now account for most production), and the Trinitario (grown in Trinidad, possibly a hybrid of Criollo and Forastero). Although there is some vegetative propagation of cultivars, most of the cacaos are grown

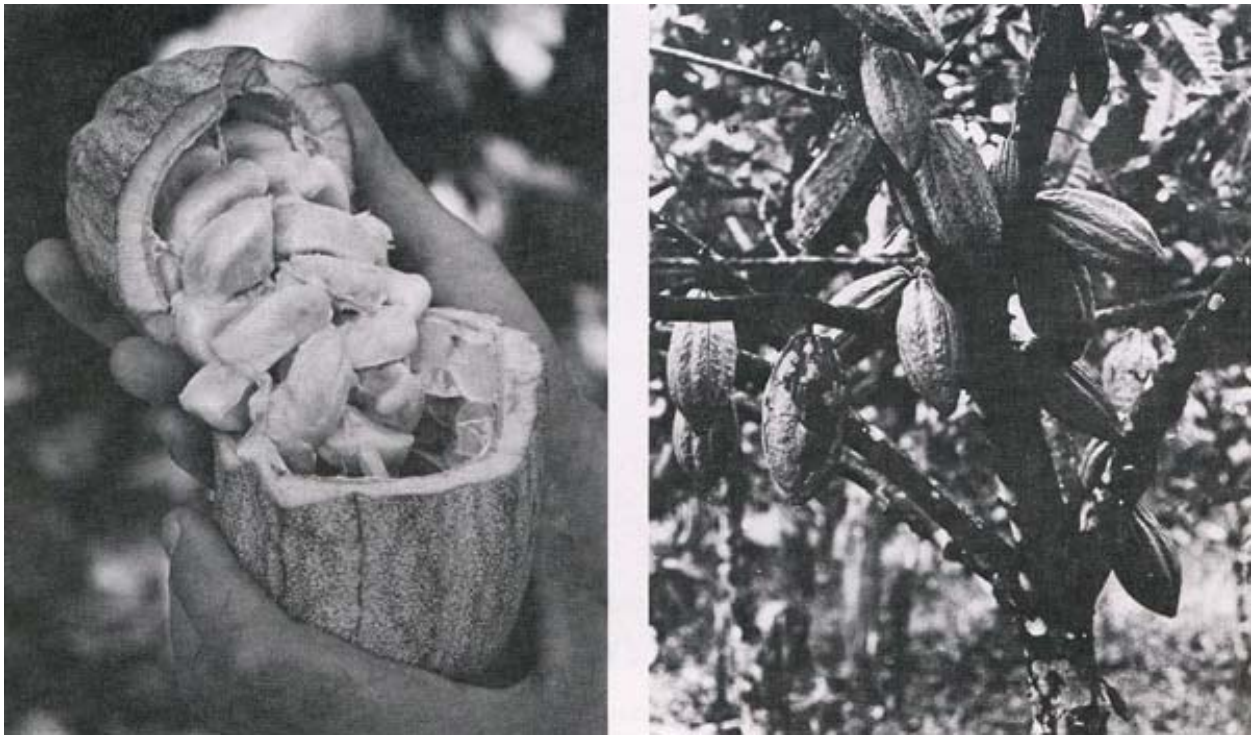

Fig. 4. Cacao fruits.

from seeds and exhibit typical seedling variability. Selection for yield and disease resistance has, however, provided superior populations to those found in the wild. The trees are believed to be partially self pollinated and partially cross fertilized, with at least the widely planted Amelonado populations reputed to be uniformly self-compatible.

Cacao is generally planted as an understory, beneath the high shade of larger trees. Plantings in full sun usually suffer more from weed competition and pests and often grow poorly, although yields may be higher if good husbandry is practiced. Fertilization improves yields. Virus and black pod diseases are the main hazards, although the pests attacking cacao are legion, Resistant cultivars are constantly being sought.

The cacao trees bear small flowers along the trunk, which, when fertilized, develop into pendulous, football-shaped fruits that hang from the larger branches. The fruits have a tough outer husk and a soft pulp that contains several seeds. A single prime tree may bear 10 or more fruits in the course of a year, providing annual yields of cacao beans that average 335 kilograms per hectare (about 300 pounds per acre) but that, in select locations, may be as high as 2.25 metric tons per hectare (about 1 ton per acre). Cacao fruits are carefully removed by hand to avoid injuring the flowering cushions along the trunk, Usually the pods are split by hand, and the seeds are hand scraped from the pulp.

The seeds are cured by subjecting them to a period of fermentation (during which unpleasant odors develop as the temperature mounts in the mounds of seeds); it is this step that helps develop the characteristic chocolate aroma. No longer viable after being cured, the seeds are then cleaned or polished further, and sent on to market. Final processing includes roasting, mechanical cracking of the seed shell, separation of the kernels, and expression of the meats to yield the oils and fats that constitute the “cocoa butter” of the trade. Typically, 50–57% of a bean is cocoa butter. This is one of the most valuable edible fats known, and it is a constituent of the finest chocolate candy. The “cake” that remains after expression is a source of the caffeinelike alkaloid theobromine. The cake may also be employed as flavoring for various products of the grocery and confectionery trade.