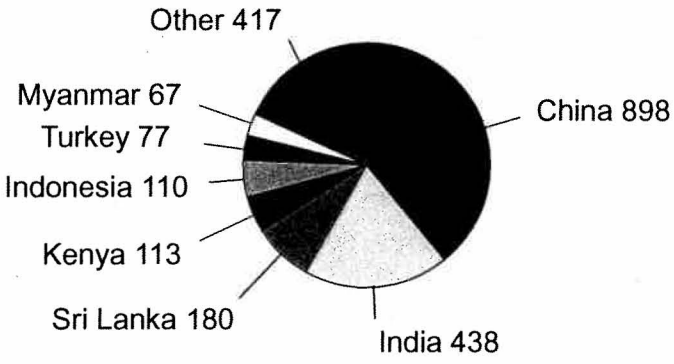
Tea *Camellia sinensis*

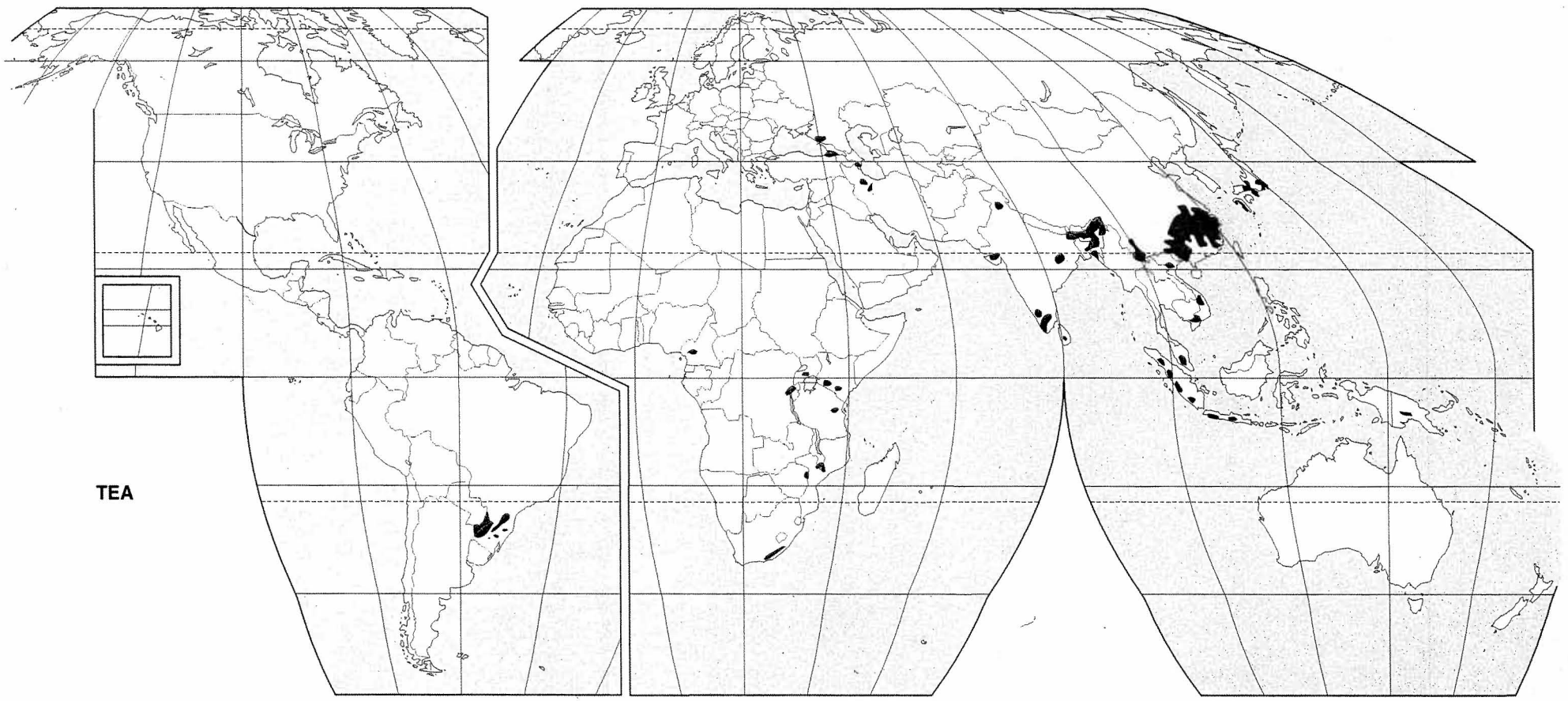
Production	
Area Under Cultivation	2.3 million ha
Global Production	3.0 million MT
Average Productivity	1,302 kg/ha
Producer Price	$802 per MT
Producer Production Value	$2,405 million
International Trade	
Share of World Production	50%
Exports	1.5 million MT
Average Price	$1,961 per MT
Value	$2,900 million
Principal Producing Countries/Blocs (by weight)	India, China, Sri Lanka, Kenya, Indonesia , Turkey
Principal Exporting Countries/Blocs	Sri Lanka, China, Kenya, India, Indonesia
Principal Importing Countries/Blocs	Russia, United Kingdom, Pakistan United States, Egypt, Japan
Major Environmental Impacts	Conversion of forest habitat Soil erosion and degradation Agrochemical inputs
Potential to Improve	Fair BMPs exist that reduce overall impacts Some effluents and soil erosion result from need for clean fields Produced in highly biodiverse areas so expansion has large impacts

Source: FAO 2002. All data for 2000.

Tea

Area in Production (Mha)





Chapter 4

Tea

Overview

Tea is the leaves of an evergreen shrub that, according to legend, was first discovered in 2737 B.C. by Chinese Emperor Sheng Nong when tea leaves accidentally blew into a pot of water he was boiling. Tea was first cultivated in China more than 2,000 years ago. It was first used as a medicine and subsequently for Buddhist ceremonies. By the fifth or sixth century A.D. it had begun to be drunk for pleasure. Tea consumption spread throughout Chinese culture. In 800 A.D. Lu Yu wrote the first definitive book on tea, the Ch'a Ching (Stash Tea 2002). The three-volume book documented a wide range of tea cultivation, processing, and preparation methods.

By the time of Lu Yu's book, tea was so important that it was taxed. Trade along the Silk Road began to involve such large quantities of tea that the Sung Dynasty (960–1297 A.D.) nationalized the tea trade. That dynasty used tea to barter with nomads for horses. Tea and salt stockpiles were even used to back the Sung Dynasty's paper money.

After seeing the value of tea in China to enhance religious meditation, the Chinese Buddhist priest Yeisei introduced tea cultivation and consumption in Japan. As a result, tea in Japan has always been associated with Zen Buddhism. Tea was embraced almost immediately by the Emperor and spread rapidly from the royal court and monasteries throughout Japanese society.

The Mongols resisted most Chinese foods with one great exception—tea. Even centuries after the Mongols had been driven from China, special tea plantations were cultivated in the north of China for trade with the Mongolians. This tea was pressed into bricks, which were used as Mongol money until the 1920s.

The first mention of tea outside of China and Japan is said to be by the Arabs in 850 A.D., and they are often credited with first trading tea to Europe via Venice in about 1559. However, because of their navigational skills and navy, the Portuguese claim to have made the first European contact with tea in China; they developed a trade route that brought tea to Lisbon as early as 1515. From there it was taken by Dutch ships to France, Holland, and the Baltic countries. When tea was first sold in the Hague, the capital of Holland at that time, it sold for $100 per pound and was distributed through apothecaries. By 1650 the Dutch introduced tea into New Amsterdam (which later became New York). By the time the English took over the colony (the Dutch having traded it for rights to the Banda Islands, the home of nutmeg, which was at that time literally worth its weight in gold), New York consumed more tea than all of England (Stash Tea 2002). The colonists continued to purchase their tea from cheaper Dutch sources rather than from the John Company, the British trade monopoly in Asia. This is the context for the Boston Tea

Party where colonists threw tea into Boston Harbor rather than pay a tax imposed by the British on tea purchased through other countries.

After 1650 tea consumption spread quickly in England. Ironically, tea displaced coffee (which had arrived in England earlier) and became the main beverage served at coffeehouses. Such houses were exclusively for men and were dubbed "penny universities" because for a penny any man could buy a pot of tea and a copy of the latest newspaper and exchange ideas with the sharpest men of the times (Stash Tea 2002). These coffee shops tended to become specialized in terms of their clientele (e.g. for lawyers, authors, military men, or businessmen) and eventually evolved into today's gentlemen's clubs. Tea gardens, by contrast, developed to serve both men and women.

Imperial Russia was the scene for another important chapter in the history of expanding tea consumption. China and Russia developed several trade agreements that opened their borders, but trade was limited by the caravan journey of 11,000 miles between the two countries, which took sixteen months. As a result of this long and complicated journey, tea was so expensive that it was only consumed by the wealthy. Gradually tea became more common and spread throughout society. In 1900 the opening of the Trans-Siberian Railroad drastically reduced the price of tea making it, along with vodka, the Russian national drink (Stash Tea 2002). The Russian samovar for serving tea is actually adapted from the Tibetan hot pot and can serve up to forty cups of tea, making tea available all day long in many Russian households.

For tea purists, the United States has had three rather dubious roles in the development of tea. At the 1904 St. Louis World's Fair iced tea was served and became a hit of the fair, and in 1908 New Yorker Thomas Sullivan developed the tea bag (Stash Tea 2002). Nearly a century later in the 1980s tea was first bottled in the United States and sold as a cold drink.

There are three varieties of the tea plant: China, Assam, and Cambodia. However, there are many different strains of these plants, and numerous other factors including soil, climate, altitude, and picking time all affect the flavor and aroma (China Tea Information 2002). Today there are countless types of tea due to these factors, processing, and the addition of flavors—an estimated 3,000 all told (Tea Glorious Tea 2002)! How tea leaves are processed accounts for enormous differences in flavor. It was originally believed that green and black tea were from different plants. In fact, they are from the same species, *Camellia sinensis* (formerly *Thea sinensis*), and their processing is what differentiates the final product. The rarest tea in the world is white tea from China and Sri Lanka. This tea is picked only at daybreak in very few places. The buds are unopened. White peony tea is made only from tiny buds picked in the early spring. The buds look like small white blossoms, and this is why they are named peony (Tea Glorious Tea 2002).

Producing Countries

Tea is grown in more than thirty countries. Globally, some 2.3 million hectares are planted to tea, and production from this area was approximately 3.0 million metric tons in 1997. The main tea producing countries in terms of area planted are China (898,000 ha), India (438,000 ha), and Sri Lanka (180,000 ha). The area in these three countries represents more than 65 percent of all land planted to tea globally and nearly 61 percent of all production. Other significant producers include Kenya (113,000 ha), Indonesia (110,000 ha), Turkey (76,800 ha), Myanmar (66,908 ha), and Vietnam (7,300 ha). These five producing countries hold 19 percent of all land planted to tea and produce 20.4 percent of the world's tea (FAO 2002). The Food and Agriculture Organization of the United Nations (FAO) estimates that by 2010 India, Kenya, and Sri Lanka will produce 70 percent of the world's black tea, and that China will produce 75 percent of all green tea (FAO 2001).

About half of all tea is exported. The five main exporters in 1997 were Sri Lanka (22 percent of global exports), China (18 percent), Kenya (18 percent), India (14 percent), and Indonesia (8 percent). Kenya, Malawi, Tanzania, Zimbabwe, and South Africa account for about 25 percent of global exports, some 250,000 metric tons (Tea Glorious Tea 2002).

Globally, production averages 1,302 kilograms per hectare per year. Bolivia achieves the highest yields with 8,675 kilograms per hectare per year. Zimbabwe (3,667 kilograms per hectare per year) and Nepal (3,632 kilograms per hectare per year) are other countries that also have high productivity.

Consuming Countries

The four largest consumers of tea are India, China, Sri Lanka, and Indonesia. The major tea importers in 2000 were Russia, the United Kingdom, Pakistan, the United States, and Egypt. Motivation for drinking tea varies tremendously. Many, of course, drink it out of habit, often because it is an integral part of their culture. Others drink tea because of its actual or perceived health benefits. Those who market tea to consumers take advantage of these reasons. In particular, health benefits are increasingly touted in tea marketing campaigns.

Some countries have strong preferences for certain teas. For example, although other teas and coffee are growing in popularity, Japan still has a preference for green tea. Japan consumes approximately 20 percent of the world's green tea. In addition, the Japanese prefer a particular type of high-quality green tea. The preference is based not so much upon the region in which the tea is produced as the method of production and processing. The Japanese prefer tea to be processed within an hour of harvest, and they follow a pest control regimen that uses up to fifteen applications of pesticide per year (O'Brien 2002).

In recent years the market share of black tea, although still the largest, has been decreasing while green and oolong tea market shares have been increasing. Oolong consumption has risen in China as well as in Japan, where 18 percent of tea consumed is oolong (Xinhua News Agency 2002).

Production Systems

Tea was originally indigenous to at least China and India. In the wild, tea grows best in warm, humid climates with rainfall of at least 100 centimeters per year. Ideally, the plant prefers deep, light, acidic, and well-drained soil. Given these overall conditions, tea will grow in areas from sea level up to altitudes as high as 2,100 meters.

Cultivated tea is generally a tropical highland crop where it receives some cooler temperatures. Tea is grown in the foothills of the Himalayas as well as in the higher elevations of China, Southeast Asia, and East Africa. The crop also grows quite well in some middle elevations in Bolivia and Guatemala. Since the tea bush totally covers the ground, it is generally a monoculture crop planted in contour rows on highland slopes.

Tea is grown both on large estates and on small farms. Small, privately held farms can be as little as 0.5 hectares or can cover several hectares. In several countries where tea is produced on small farms, cooperatives have usually been formed to build a central processing plant, assist with technology transfer, and to market the product.

A tea estate, by contrast, is a self-contained unit. It is often hundreds, sometimes thousands, of hectares in size. Large tea estates are found in several countries in South and Southeast Asia, East Africa, and Latin America. In addition to the extensive tea plantings, an estate also has its own factory for processing as well as schools, a clinic or hospital, staff houses, gardens, woodlots, reservoirs, places of worship, and guest houses (Tea Glorious Tea 2002).

In Assam, India, one of the best-known tea producing regions, there are 655 estates that manage 168,000 hectares of tea or 42 percent of all the tea cultivated in India (Tea Glorious Tea 2002). In Darjeeling, tea is produced on 100 estates with some 18,000 hectares of plantings, generally at about 2,100 meters (7,000 feet) elevation. By contrast, in the south of India in Nilgiri, more than 20,000 small farms grow tea on some 37,000 hectares (Tea Glorious Tea 2002).

Tea is grown as a bush that is allowed to grow about 1 meter high. This makes it easier to pick. Bushes are mostly grown from cuttings or clones, which are tended in nurseries until they are ready to be transplanted. Bushes are planted about 1.5 meters apart in rows that are 1 meter apart. On steeper slopes the rows follow the contours to minimize soil erosion (Tea Glorious Tea 2002). On even steeper slopes, terraces are also built to avoid soil erosion.

The tea bushes are trained into a fan shape with a flat top. This is referred to as the "plucking plateau." It is about 1 meter by 1.5 meters in area and takes from three to five

years to come to maturity, depending on the altitude. Before the first picking, the bushes are severely pruned. Tea bushes produce for a long time, varying from approximately 40 years for the Assamese variety to over 100 years for the Chinese variety. Bushes will produce even longer than this, but their harvest may not be economically viable (Tillberg 1995).

Bushes are picked, mostly by hand, every seven to fourteen days. Altitude and climatic conditions of the growing area are the two factors determining the length of the regrowth period. A tea bush grown at sea level will replace itself more quickly once plucked than a tea bush growing at a higher altitude where the air is cooler. Only the top two leaves and a single bud are picked from each sprig on the plucking plateau (Tea Glorious Tea 2002). In Japan a mechanical harvester/leaf cutter has been developed that makes the picking of young leaves easier.

The picked leaves are collected in a basket or bag that is carried on the back of the pickers. When this is full it is taken to a collection point where the picked leaf is weighed before being transported to the factory for processing, or "making," as tea blending and manufacturing is known in the tea trade (Tea Glorious Tea 2002). When pickers are on estates and near the factory they will take their leaves to the factory directly to be weighed. On an estate, each picker is credited with the weight of the tea they pick. A skilled picker can pick 30 to 35 kilograms of leaves in a day. This makes about 7.5 to 9 kilograms of processed black tea.

Large estates tend to dominate tea farming in Asia and East Africa and therefore tea is planted as a monoculture crop there. Since tea is a deep-rooted evergreen shrub, soil erosion is rather minimal. However, some erosion still occurs because there are inevitably some exposed areas, such as paths that are used as walkways or areas that are being planted or rehabilitated. Large tea estates can extend as much as 20,000 hectares of monocrop plantations. In such areas, very little biodiversity is visible. From horizon to horizon there is only tea.

While few herbicides are used in tea production, there are several problems with soil-borne fungal diseases and nematodes. As a consequence, a number of applications of fungicides and nematicides on the soil are generally used. When applied over large sloping areas, this can create a big problem of pollution and runoff of the pesticides to the streams and waterways.

Processing

It is in everyone's interest that tea is harvested so as to maintain the high quality of the product and that this quality is maintained right up to the point of use by the consumer. The first stage in product processing and maintenance of leaf quality is with field harvesting and leaf transport. The goal at this stage is to insure that all harvested leaves are acceptable for tea manufacture. This means that foreign matter, including leaves from other plants grown for shade, fuelwood, or windbreaks, should never be present.

Pesticides banned either in the country of production or the country of consumption should never be present.

There are three main ways to process tea. These yield green tea, black tea, and oolong tea. All start in more or less the same way. Tea leaves are brittle when fresh and are withered either in sunlight or in warm air. This makes them pliable enough to be handled. The leaves are then rolled, twisted, and slightly broken. Often this is done by machine. The essential oils that give tea much of its flavor come out at this point. If the tea is fired or dried at this point the result is green tea. All Japanese tea and most forms of Chinese tea are green tea. Prior to 1830 Americans drank mostly green tea. That declined, however, so that until recent decades almost no green tea was consumed in the United States. Today green tea is again becoming more common.

Tea leaves turn black when the oils are exposed to air. Oxidization not only darkens the color, it also allows the leaves to develop new flavor compounds. These are commonly known as tannins, though technically they are called polyphenols. This black tea is what most Americans drink today. The British introduced large-scale tea production into many parts of India and Ceylon in the early 1800s. The harvest was processed as black tea.

The third processing method produces oolong tea. The tea is allowed to partially oxidize so that some of the fresh flavors of green tea are still there as well as some of the deeper flavors of black tea. This tea is produced in China and Taiwan, and some consider this middle-of-the-road tea to be the most sophisticated of all.

On arrival at the factory, the leaves are spread on large trays or racks; these are placed in the top of the factory where the leaves wither in temperatures of 25 to 30 degrees Celsius. As the moisture evaporates over the next ten to sixteen hours each leaf becomes limp. Some factories add warm air or fans or both to hasten the process. The leaves are then broken by machine to release the natural juices, or enzymes, that oxidize on contact with the air. "Orthodox" machines roll the leaves and produce large leaf particles or grades. "Unorthodox" machines produce finer cuts or chopped particles. The smaller particles are more suited for quicker brewing products such as tea bags (Tea Glorious Tea 2002).

The broken leaves are then laid out again on trays in a cool, humid atmosphere for three to four hours to ferment, or oxidize, and are gently turned throughout this process. The turning assists an even, golden russet finishing when the fermentation process is complete (Tea Glorious Tea 2002).

After fermentation, the leaf is dried thoroughly by passing it through hot air chambers where all remaining moisture is removed and the leaf turns very dark. The leaf is deposited into chests, where it is stored until it can be graded for size by passing it through a series of gradually larger fine wire meshes. After this, the tea is weighed and packed into chests or sacks for loading onto pallets. Samples of each tea are kept aside, which can be used to market the different lots of tea. Once a "make" has been processed, the factory is thoroughly washed down so that the next lot will not be contaminated by the last one (Tea Glorious Tea 2002).

In the end, most tea is blended with leaves from different pickings and grown on different topography. Such blends can include twenty, thirty, or even more sources of tea, most of them black. Hundreds of flavors can also be added to tea or blended with it. Many of today's common teas actually originated as common grading, flavor descriptors or processing terms (e.g. Pekoe, Orange Pekoe, or Earl Grey) or the names of places (e.g. Yunnan, Assam, Darjeeling). It is the job of the blender, a taster with many years of experience (it takes five years of training to become a novice), to insure brand consistency.

During processing, many teas are flavored. Earl Grey, a blend of black teas, is flavored with oil of bergamot, a variety of citrus fruit whose oils are commonly used to scent perfumes. Jasmine tea is probably the most common scented tea. Traditionally it was made by rubbing jasmine petals into the steamed leaves of green or semifermented tea, sometimes as much as seven times. Manufacturing jasmine tea today tends to involve the rolling of leaves in tumblers with jasmine flowers. Lapsang Souchong is tea smoked with slow-burning pine logs. Mint tea, consumed in North Africa, is actually several varieties of black tea that are mixed with either fresh or dried mint leaves. And chai, a generic name for spiced tea in India, is made with black tea, milk, and sugar as well as some combination of cinnamon, cardamom, cloves, and white or black pepper. Sometimes fresh ginger is added.

Processing tea causes fewer environmental problems than the processing of most commodities. Because tea leaves are rather small and easy to dry, drying is not a very energy consuming activity. However, it is important that the tea is not over- or under-dried, and it is important that it is not tainted in any way during processing. Solar dryers and passive solar dryers have been developed to dry tea, but these are not terribly widespread. During processing a certain amount of dust, twigs, and organic matter is removed. This organic matter is the only waste that is created. Very little water is used in the processing of tea. Another major processing issue is product quality from a health and safety point of view. Tea must be within acceptable limits of microbiology and free from heavy metals, foreign matter, and any substances that are potentially harmful to consumers.

Substitutes

There are many substitutes for tea as either a hot or a cold drink. Traditional herbal teas were used as medicines, and they still are in many parts of the world. Increasingly, however, herbal teas are being consumed more commonly in their own right even though they are often marketed for their health or well-being benefits. Common herbal teas include chamomile, peppermint, spearmint, rose hips, and lemon verbena. In addition, a wide variety of herbal blends are now sold by distributors of standard teas.

There are several other substitutes for tea that are also sources of caffeine either in the form of hot or cold drinks. Maté is an herbal tea from South America with very high caffeine content. One gram of dried yerba maté leaves contains approximately 15

milligrams of caffeine (Stash Tea 2002). Guarana is a drink in the Amazon that is quite high in caffeine, with 25 milligrams of caffeine per gram of the dried seed (Stash Tea 2002). Perhaps the two most important sources of caffeine are coffee and cocoa. An 8-ounce cup of coffee has 135 milligrams of caffeine on average. While a cup of hot chocolate or cocoa has only 5 milligrams, a 1.5-ounce dark chocolate bar can contain 31 milligrams of caffeine, as much as a cup of green tea. In comparison, a cup of black tea typically contains 50 milligrams of caffeine, but it can vary from 25 to 110 mg depending on how long it is brewed (CSPI 1997).

Perhaps the most important substitutes for tea, however, are sodas. The consumption of sodas has increased more rapidly than any other drink in most countries. This is not only true in Europe and North America but also in developing countries. In Mexico, for example, the population is purported to drink more soda than water. Even with the rapid proliferation of numerous alternatives, tea consumption is holding its own.

Market Chain

Tea is sold in a variety of ways. From 1706 to 1998 the London tea auction was one of the main auctions for tea and was known for setting the price worldwide. Over time, auctions opened up around the world closer to the areas of production. Today tea is most often auctioned in the country of origin. Auction centers exist in Mombasa, Kenya; Colombo, Sri Lanka; Limbe, Malawi; the north and south of India; Jakarta, Indonesia; and Guangzhou, China. Prices are governed by quality, supply, and demand. Tea brokers act as intermediaries and taste, value, and bid teas on their different client's behalf. Tea may also be sold by the estate producer at a private sale or while en route to its destination (Tea Glorious Tea 2002). After arriving in the main consumer centers, the tea is taken to the packaging and blending companies.

Tea-packaging companies sell their tea directly to supermarkets and other retailers. They sell through wholesalers as well as teams of salespeople calling on small retail shops and restaurants. Some of the packaging companies have significant market share. For example, Unilever, through such brands as Lipton, has 20 percent of the value of the world market for black tea (Unilever 2003a).

Most tea reaches the supermarket shelf between twenty and thirty weeks after it has been plucked (Tea Glorious Tea 2002). For best flavor tea should be consumed within six months of purchase, or within one year of being picked.

Market Trends

Global tea production increased from 3.0 million metric tons to 3.1 million metric tons between 2000 and 2001. Increases in tea production, combined with relatively constant consumption and global demand, caused tea prices to continue to decline in 2001. On a global level, the FAO composite price in 2001 was 13 percent lower than the annual

average in 2000. In some areas, however, such as Sri Lanka, due to local exchange rates there were price increases in the local currency (CFC 2002).

By 2002, however, there were indications that prices may be rising. Some of the main tea producers—India, Kenya, Bangladesh, and Indonesia—had a decrease in production during the first nine months of 2002 as compared to the previous year. Forecasts for an early winter in India dampened hope that producers would be able to make up for lower overall production in 2002. Sri Lanka was the main exception to declining production as producers there had slight production increases (*Financial Times* 2002).

Once primarily consumed in Asia and North Africa, green tea is becoming increasingly available around the world. Green tea production is projected to increase at a 2.6 percent average annual growth rate between 2000 and 2010, considerably faster than the 1.2 percent annual growth rate estimated for black tea over the same period. Black tea production estimates for 2010 are 2.4 million metric tons; this is still much larger than the relatively small market share of green tea, which has an estimated production for 2010 of 900,000 metric tons. On the whole, green tea exports are expected to increase along with production increases. Some countries, however, such as Japan, are likely to consume the majority of their domestic production (FAO 2001).

A prime driver of changing consumption patterns is the increased knowledge about and marketing of the health benefits of green tea. Studies show that green tea is high in vitamins and minerals, particularly vitamins B and C, as well as being high in fluoride. Researchers have found that both white and green teas are high in antioxidants; white tea is three times more so than green tea. Both are also used increasingly in anti-aging formulas (Dietz 2002). Among the health claims made of green tea are that it is thought to prevent skin cancer and lower blood pressure. Lotions, perfumes, other beauty products, and energy bars are among the many products on the market today that contain green tea (Stash Tea 2002).

Another potentially important trend in the industry is the increase in organic tea production. Market demand for organic tea in 2001 was more than 3 million kilograms, up from 150,000 kilograms in 1981. The Tea Board in India has recognized this market and is promoting organic production. For example, they plan to convert 100 hectares in each of three regions to organic production as part of a project they are undertaking with the Common Fund for Commodities (Global News Wire 2002).

Environmental Impacts of Production

The main harmful environmental impact of tea production is habitat conversion. This is especially true for tea because much of the habitat used for cultivation is often located in more rugged and remote areas, which tend to be those with the highest biodiversity. Converting rugged natural habitat to tea production has multiple effects. Not only are the number of species reduced, but also, due to the slope of the land, considerable soil is lost before the plantations are fully established to protect the soil. As a consequence, a fair

amount of soil degradation can occur. Energy use is another environmental cost. All tea must be dried. Wood is usually the source of energy for this, and as a result drying can lead to localized deforestation. Finally, there is some waste that results from processing tea, but since it is organic matter it can be easily reintegrated as a soil amendment depending on its acidity.

Habitat Conversion

As with any crop that is grown by itself in monocultural production systems on a large scale, habitat conversion and associated biodiversity loss is an issue. In Uganda and Kenya large areas of natural forests were cleared to make way for tea plantations. Tea-growing regions in India were once covered with a variety of grasslands, marshes, and forested areas that hosted a wide range of flora and fauna that included such species as elephants, tigers, and deer. Today the landscape is dominated by vast tea fields (Chaudhuri 2002). Tigers are no longer found in tea-growing regions. In addition, single tea crop cultivation does not support the same ecosystem functions as natural habitat. For example, it has less water retention and increased water runoff and soil erosion than more biodiverse natural habitats.

Agrochemical Use

The chemical inputs applied on tea plantations have had a deadly effect on soil biodiversity while simultaneously polluting river water, killing fish, and harming the animals and people who depend on the rivers for water. Agrochemicals used on tea plantations kill many of the microorganisms that live in soil. Studies in India have shown that as much as 70 percent of soil biota have been lost on tea plantations as compared to nearby natural habitat, especially in areas that workers and machinery pass over (Senapati et al. 2002). The use of chemical fertilizers has resulted in a decline in soil fertility (Fareed 1996).

In India as well as other producing countries, the tea industry has, until relatively recently, used pesticides that had been banned in developed nations. Such chemicals can have effects on human health through run-off as well as direct exposure when in the fields and spraying. Among the pesticides used were synthetic pyrethroids, which, in addition to posing health risks to the immediate environment, can also be quite toxic to fish and downstream organisms, certain beneficial insects such as bees, and even deplete the ozone layer (Fareed 1996).

Degradation of Soil

Monocrop production and its associated chemical inputs not only reduce soil biodiversity and soil organic matter, but also compact soils (especially in areas that workers and machinery pass over). Compacted soils are low in oxygen. Earthworms can play an important role in oxygenating soil and are commonly used as an indicator of soil health. Researchers have found that tea plantation soil contained between one-third and one-half the number of earthworms per square meter as the nearby natural forest soil. In addition,

most earthworms found in tea plantations were not native species to the area (Senapati et al. 2002).

Although well-established tea plants are deep-rooted and provide good ground cover, both of which minimize erosion, areas where tea is being planted or replanted are vulnerable to erosion. A study of soil erosion in Sri Lanka focused on tea, rubber, and coconut plantations. Of these three crops' overall growth phases, tea that was replanted on steep slopes had the highest erosion rates, whereas well-established tea had relatively low erosion rates (UNESCAP 2002). Not only does erosion strip nutrients and topsoil from the agricultural fields, it also causes problems downstream. In Sri Lanka, siltation from erosion is a major problem. Silt fills reservoirs, which reduces hydropower generation and the life of hydroelectric dams (UNESCAP 2002).

In southern India where some tea estates are more than 100 years old, the soil has become impoverished and yields are stable despite the increasing application of fertilizers and pesticides. According to Senapati et al. (2002), soil degradation includes, in addition to those factors mentioned above, reduced cation exchange (a measure of a soil's ability to hold stores of nutrients and release them to plants), reduced water absorption and retention, increased acidity of the soil (pH as low as 3.8, which causes concentrations of aluminum to increase to toxic levels), nutrient leaching, and accumulation of natural toxins from tea leaves which can begin to alter microorganism soil communities.

The degradation of tea plantation soil is a cycle that feeds upon itself and increases the environmental degradation from tea production. As the soil is degraded, farmers increasingly rely on chemical inputs to maintain productivity. These inputs then contribute to further soil degradation, which leads to decreased productivity, requiring still more inputs to maintain a profitable tea plantation. As the soil degrades, more and more of these inputs are eroded or washed away, entering local water systems and harming the local environment. Some tea plantations are now trying alternative methods to restore soil health and increase productivity from the ground up.

Use of Wood for Drying

Tea processors use various fuels to dry tea leaves. Wood is the most common energy source, though some processors use both gas and wood, or only gas or oil. Large amounts of wood are used to dry tea, and how the wood is harvested has large implications for its environmental impacts. Most of the wood that is used for drying tea comes from harvesting in natural forests. As wood supplies decrease, however, tea plantations are now planting trees to provide their own wood.

In Sri Lanka it takes between 1.5 and 2.5 kilograms of wood to produce 1 kilogram of tea. The tea industry used more fuelwood than any other industry in Sri Lanka in the mid-eighties, some 377,400 metric tons per year and 33 percent of total fuelwood consumption by industry (FAO 1987). By 1992 the tea sector's use of fuelwood had increased to 455,000 metric tons per year, consuming over 43 percent of the fuelwood used by industry. Hotels and restaurants were the second largest wood users, consuming 15 percent of the total and 164,000 metric tons annually (FAO 1999).

Processing Waste

Processing activities in the tea sector do not pose significant environmental problems. In fact, those activities have been categorized as "low polluting" by Sri Lanka's Central Environmental Authority (UNESCAP 2002).

Tea waste is the sole tea processing by-product. It is mixed with lime before being dumped. This alters the soil pH, making it unsuitable for tea cultivation (Fareed 1996), but it is still a valuable soil amendment for any other crop that does not require soil to be as acidic as tea. In addition, tea production machinery is cleaned using a detergent that has a caustic soda base, which is often dumped untreated into local water systems (Fareed 1996).

Better Management Practices

Several ways have been identified to reduce significantly the environmental impacts of tea production. Unilever (2003b; 2003c) has, in fact, developed a set of better practice guidelines to help producers who want to sell to them to reduce their overall impacts. These guidelines are summarized below. In general, the better practices allow producers to encourage and increase biodiversity within their plantings. This is important because much of that biodiversity helps reduce the need for pesticides and other inputs. Other important practices, however, are those that reduce soil erosion and degradation and actually build soil so as to reduce the need for fertilizers and other inputs. In addition, farmers have found more efficient ways to utilize inputs (e.g. fertilizers, pesticides, energy, water, and some of the more toxic chemicals) so that they can get by using less of each.

Conserve Biodiversity

The conservation of biodiversity in the plantation and surrounding areas is important, particularly where plantations are located in areas of high conservation value. The principle should be that the land is being borrowed from nature and that if production of any kind ends on it, the land could be repopulated with a good representation of local biodiversity in a relatively short time. Improving yields on existing plantations can reduce pressure to convert natural habitat to tea plantations. For example, 1.2 percent per year increases in black tea production from 2000 to 2010 are expected to come from improved yields rather than increased planting and habitat conversion.

Producers should reduce pesticide use, abandon illegal pesticides entirely, adopt integrated pest management (IPM) whenever possible, adopt conservation measures for rare or endangered species that are on the farm or that use it as habitat, and work with initiatives that encourage biodiversity. Before new areas are planted, environmental impact assessments should be undertaken and the recommendations followed. While this may be unnecessary for small farms, the principle is that the biodiversity implications must be considered before any new plantings are undertaken.

Riparian areas should be maintained and continue to be dominated by native species. Similarly, areas that are too steep to plant should be left in native habitat. Wherever possible these wildlife habitats should be connected through corridors, not only on the same farm but between farms as well. When planting trees for fuelwood or for windbreaks, native species should be used whenever possible.

Another way to enhance biodiversity within existing tea estates is for producers to abandon tea growing in areas that are unprofitable (e.g. steep slopes, shallow soils, alkaline soils, poorly drained lands, etc.). In many instances, farming these areas takes producers' energy away from more productive parts of farms. Abandoning such areas will often result in higher net producer profits.

Promote Crop Diversity

The number of commercially viable plant species and varieties cultivated for human use is declining each year. An important conservation strategy, particularly with a long-lived plant like tea, would be to save a small patch of 50 to 100 bushes of older varieties of tea in any area that is targeted for replanting. This will save genetic material that may be useful for future tea propagation and production (for example, to develop varieties that are resistant to diseases that become problems in the future).

Reduce Soil Erosion and Degradation

Soil erosion can be high in tea plantations. They are often planted in areas of considerable slope that receive high levels of rainfall. Erosion is most extensive during periods of planting or replanting, when as much as 75 metric tons of soil per hectare per year can be lost, as compared to 20 metric tons or less for well managed seedlings or vegetatively propagated tea (UNESCAP 2002). It is important that ground cover be maintained at all times. If an area has to be replanted, the exposed ground should be mulched and replanted with vegetation as quickly as possible.

If the land being planted slopes significantly, then planting should be undertaken on the contour. This is particularly important on slopes that are over 25 degrees (in fact, a rigorous analysis should be undertaken to insure that such slopes are even economically viable for planting in the first place). On particularly steep slopes, single bands of a grass such as napier (*Pennisetum purpureum*) can be established every five to ten rows of tea to supplement contour planting. The grass can be harvested for mulch or for fodder.

Several other practices can be used to reduce erosion:

- Environmental impact assessments can help identify problematic areas of concern.
- Digging silt pits in newly planted areas can arrest run-off and encourage water retention.
- Mechanical harvesting should be avoided in any areas where soil erosion is likely to be severe.
- Ground cover plantings along field edges should be used to reduce erosion.
- Careful siting and construction activities (e.g. drain design, road and path layout, etc.) can reduce soil erosion significantly.

- Tea prunings can be used to cover all bare soils to prevent soil erosion.
- Soil should not be taken from fields for use in nurseries. This material can just as easily be created from compost mixed with soil in the nursery area.

Senapati et al. (2002) report that several research projects begun in 1991 on six estates in southern India indicate that there are several ways to restore soil fertility and enhance tea production. The application of organic matter to the soil appears to have great potential to increase soil microorganisms and earthworms. In general, more earthworms present in the soil mean higher total green leaf tea yields. As soils are degraded their earthworm populations decline and termite populations increase. As a result, the proportion of termites to earthworms appears to be a good indicator for assessing soil degradation. Yield increases from bio-organic fertilization ranged from 75.9 to 282 percent. This produced profits of U.S.$5,500 per hectare per year compared to conventional cultivation with standard synthetic fertilizers. Such bio-organic fertilizers can be made by composting tea prunings and high-quality organic matter, and mixing the material with earthworms. This was shown to be a more effective way to increase yields than the application of fertilizers alone. Different field trials showed that yields were increased from 79.5 to 276 percent over conventional fertilizer use alone. The vegetative propagation of tea allows both for quicker growing and ground cover establishment.

The adoption of these practices can increase production by 50 percent. However, in addition to increased production, producers also restore their land, improve the quality of their leaf, and conserve soil. The combination of these factors will increase the net value of production both in the short and medium term.

One of the main measures of soil health and fertility is the content of organic matter, so management should be focused on maintaining or increasing organic matter. In addition, deterioration of soil structure may result from compaction, especially from harvesting mechanization, from changes in pH, from salinity, or from exposure. Mulching with tea prunings, planting shade trees, and leaf or other organic litter, or even planting cover crops for two years prior to replanting of tea plantations, can also increase organic matter.

Reduce Fertilizer Use

Financial sustainability of tea production may require the use of fertilizer on some soils, especially over time. In India, for example, higher levels of fertilization are required to make plantations financially viable. However, the principle should be that nutrient inputs should not exceed off-take in the harvested product. Efficiency will depend on the application rate, soil type, soil depth, slope, temperature, and climate. In order to achieve this, nutrient loss through wastes, erosion, effluents, and soil exposure at the time of replanting must be minimized. In addition, because applied nitrogen is so volatile, every effort should be made to increase nitrogen through biological fixation. Application of fertilizer should be avoided within 3 to 4 meters of freshwater systems. Algal blooms in ponds within the farm are an indication of contamination from fertilizer runoff, particularly nitrogen.

In Kenya, about 80 percent efficiency of input use has been achieved by keeping fertilizer applications at an average of 150 kilograms of nitrogen per hectare per year or less.

Careful timing of fertilizer applications and monitoring of the crop can also help reduce fertilizer use. For example, in Kenya, a yield of green leaf of less than 6,500 kilograms per hectare per year is an indication of inadequate fertilizer; dark green, fleshy and succulent shoots throughout the sorting table are an indication of excess applications of nitrogen.

Ash from eucalyptus (or other fuelwood) from dryers or from old tea plants is a potential source of potassium, a nutrient essential for plant growth. However, ash is alkaline, and tea plants do not benefit from the added alkalinity (unless soils have become extremely acidic). Instead of using it on the plantations, the ash should be used on the soil of the trees grown for fuel plantations, which will improve fertility in the fuelwood plantings.

The application of organic matter and compost can reduce the requirement for inorganic fertilizer applications. This results in part because the application provides needed nutrients. In addition, however, the organic matter binds with nutrients in the soil as well as those added subsequently, effectively increasing the soil's nutrient-holding capacity.

Another way to reduce fertilizer use is through the choice of appropriate nutrients. For example, ground rock phosphate applied where soil is acidic during land preparation before planting or replanting reduces the subsequent reliance on soluble phosphate fertilizer, which is more easily leached into nearby streams and ponds.

Similarly, if soils are or become extremely acidic (below pH 4), lime should be applied at the time of pruning. Dolomitic rather than burned (quick) lime should be used if available. It will release more slowly in the soil and so tend to require fewer applications over time.

Minimize Pollution from Energy Consumption

Renewable energy resources should be targeted for use since nonrenewable sources such as fossil fuels are not sustainable in the long term. Wherever possible the use of fossil fuels for power generation, vehicles, irrigation engines and factory startup and operation should be minimized to reduce pollution and production of greenhouse gases. Solar, wind, and hydroelectricity should be explored as possible alternatives whenever possible. In some areas, biofuels derived from wastes could supplement fuelwood use. In addition to the source of energy, the boiler and factory energy efficiency should be optimized.

Using wood for drying is a preferred way to reduce nonrenewable energy sources provided the fuelwood is sustainably harvested or derived from managed plantings specifically dedicated for that purpose. In the case of small farms, cooperative fuelwood production schemes could be considered. However, if the only option is to derive wood from protected areas or other fragile forest ecosystems, then fossil fuels should be used as the preferable alternative.

Reduce Water Consumption

Water consumption may be an issue in some areas, primarily as a result of irrigation and especially through extraction of ground water. Both the volume of water used and the

ratio of renewable to nonrenewable water used need to be considered. Water can be harvested from building roofs or even from retention ponds built in runoff areas of the property away from streams. It is an important principle to insure that water use is not at the expense of downstream users. In some instances, simply making workers aware of the importance of an issue by measuring it is the first and most important step in reducing overall consumption.

There are a number of ways to reduce use. Drip irrigation uses less water than sprinklers. Water use in the factory can be reduced by condensing and reusing the steam from the drying tea leaves, and by dry-cleaning or brushing the factory lines where product is moved, processed and packaged rather than washing them with water.

Water pollution is also an issue. When caused by inappropriate timing of fertilizer applications or field renovations, it can be reduced by the soil conservation methods described above and especially by increasing organic matter in soil to retain both water and nutrients. Or it can result from high biological oxygen demand, as in the effluent resulting from flushing organic matter during processing. One way to avoid this would be to establish water catchment areas to allow organic matter to decompose and settle out rather than simply allowing it to be flushed down stream.

Reduce Use of Toxic Chemicals

While there will be times when pesticides will be necessary for the production of tea, such chemicals should never be used prophylactically. Integrated pest management (IPM) can be the key to reduced toxicity and more sustainable pest control for tea production. For this to work, however, producers must not only identify the main pests in the different areas of the plantation but also develop management plans for controlling them. This means the development of censuses and analyses of the life cycles and natural enemies. Economic damage thresholds must be established for each pest with appropriate control measures indicated for each. Research on biological control agents (e.g. predators, parasites, biological fungicides, and pheromones) will need to be undertaken on a wide range of tea growing areas. In addition, positive results and field trials should be incorporated into IPM practices so that improvements can be identified and adopted over time.

Even the most effective IPM strategies will not eliminate the use of pesticides, but they can insure that pesticide applications are kept to a minimum. This in turn will minimize seepage into groundwater or runoff into freshwater systems. In some areas, like East Africa, diseases and insect pests are not a major problem. In such areas, IPM should be used to keep the natural enemies of tea in check and minimize the need for toxic chemicals.

If herbicides are required, safer compounds should be targeted whenever practical. Low volumes and spot applications can be used to reduce overall impacts. Applicators should practice with the equipment to insure they are competent to use it and understand how to protect themselves. For small farms, manual weeding is recommended. This reduces the costs of herbicides, application equipment, and protective clothing.

There are other ways to control pests. In some cases, weeds may become an issue in mature tea plantings as a result of pruning. A longer pruning cycle, or a taller pruning height, results in more complete shading by the tea and thus fewer weeds.

Outlook

Tea consumption is expected to increase moderately over the next few decades. Most of the increases can be accommodated by increasing productivity in existing tea plantations. It is highly likely that many tea consumers, particularly in Asia, will begin to consume increasing amounts of coffee and cold beverages in the future.

While the overall consumption of tea is not likely to increase much, the quality of tea consumed is likely to increase significantly. If the consumption of coffee and other beverages in developed countries is any indication of trends in tea consumption, individual tea drinkers will more likely drink less tea in the future but want a higher quality product, for which they will be willing to pay significantly more. While this has already happened in developed countries, it is likely that it will begin to happen in China and India as well as those economies grow and consumers have more disposable income. What this means is that production and processing will need to be improved across the board to meet the increasing consumer demand for high-quality teas.

Resources

Web Resources

www.tea.co.uk
www.teahealth.co.uk
www.communityipm.org/docs/Tea_Eco-Guide/16_Contents.PDF
www.stashtea.com
www.teas.com

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