As. J. Food Ag-Ind. 2008, 1(01), 1-16

Asian Journal of Food and Agro-Industry
ISSN 1905-
Available online at www.ajofai.info

Article

Development of the tea industry in Thailand

Terry Commins[1*] and Sailom Sampanvejsobha[2]

[1]Pilot Plant Development and Training Institute
King Mongkut's University of Technology Thonburi
Pracha Uthit Road, Bangmod, Tungkru, Bangkok 10140, Thailand

[2]Mae Fah Luang University
Chiang Rai, Thailand

*Author to whom correspondence should be addressed, email: thefox@loxinfo.co.th

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Abstract: Tea is emerging as an economically important crop in Thailand and is earning a significant share of the beverage market. This paper attempts to explain in simple terms how tea came about, what is involved in tea cultivation, processing and marketing, as well as point the way for what might be done in support of the industry.

Brief History of Tea

The consumption of tea had its first beginnings in China over 5,000 years ago. It began as a hot beverage made from the leaves of the shrub *Camellia sinensis*. Around 800 BC, Lu Yu produced the Ch'a Ching – the first comprehensive book on the subject. Lu Yu was strongly influenced by his early Buddhist education. Tea was first introduced into Japan by a Buddhist priest and in that country the tea ceremony (cha-no-yu) has since been raised to a high art form, with Zen Buddhists playing an influential role throughout its history.

Tea was first introduced into Europe from China by a Portuguese Jesuit priest in 1560. It first became available through apothecaries until over the next century it became available to all levels of society and was regarded as a food. As early as 1635, doctors and scientists in Europe argued over the merits and demerits of tea consumption. Until the Sixth Century, tea was consumed primarily as a remedy for headaches, kidney trouble, poor digestion, ulcers and to guard against "the noxious gasses of the body and lethargy".

Interestingly, it is claimed that tea was introduced into New Amsterdam (now New York) in 1650 by the Dutch and it did not reach England until 1652, where it quickly became the national drink. It was preceded by coffee. England formed the John Company (later merged with the East India Company in 1773), the single most powerful monopoly in the world; a monopoly based on tea. Tea houses in Europe became denizens of free speech where the roots of democracy took hold. The tradition continues in Burma to this day. Russia became, and remains, a major tea consumer. The American Revolution started over a tax on tea.

Following the Opium Wars, a Scottish botanist smuggled some tea seeds out of China and introduced the crop to India where, through trial and error, growing and harvesting techniques were perfected. From India, tea cultivation quickly spread to other suitable areas in Asia.

What is Tea?

When cultivated for harvest, tea bushes are kept to a height of about one metre. One tea bush will continue to produce for a minimum of 50 years. There are over 3,000 varieties of tea each with their own specific characteristics. Not unlike wine, tea comes from one bush, and where the tea is grown, the climate, soil conditions and how the tea is processed, determines the flavor characteristics of the tea.

The tea planter recognises three varieties, China, Assam and Indo-China, and hybrids between them all. Within the Assam variety, five types are recognized, the light- and the dark-leaved Assam, the Manipuri, the Burma and the Lushai. The Indo-China variety is sometimes referred to as the Cambodian or Southern form. However, planters usually do not refer to varieties, types, races, agro-types or ecotypes. They use the term *jat* for any group, though agro-type might be a better term. Tea seed is sold under the name of the estate on which it is grown, and this is also spoken of as the *jat* of the seed.

Tea is harvested after each flush of new growth - the sprouting of the top two leaves and the bud. The top two leaves and bud are hand plucked and then processed into any of the four types of tea, which are Black, Green, Oolong, and White. Experienced pickers can harvest around 30kg per day, by hand. First flushes provide the highest quality and demand the highest price, while second flushes are regarded as slightly inferior.

Black tea is withered, fully oxidized and dried. Black tea yields a hearty, amber-coloured brew. Some of the popular black teas include English Breakfast and Darjeeling. Black tea has the highest concentration of essential oils and least resembles the natural leaf.

Green tea skips the oxidizing step. It is simply withered and then dried. It has a more delicate taste and is pale green/golden in color. Green tea currently makes up around 10-20% of world production.

Oolong tea, popular in China, is withered, partially oxidized, and dried. Oolong is a cross between black and green tea in color and taste.

White tea is the least processed. A very rare tea, mainly from China (Fujien), White tea is not oxidized or rolled, but simply withered and dried by steaming. Sri Lanka also produces a small quantity of white tea.

The four main types of tea are distinguished by their processing. The leaves, if not quickly dried after picking, soon begin to wilt and oxidize and starch begins to be converted into sugars. The leaves turn progressively darker, as chlorophyll breaks down and polyphenols are released. The next step in processing is to stop the oxidation process at a predetermined stage by removing the water from the leaves via heating. Without careful moisture and temperature control, fungi will grow on tea. The fungi will cause fermentation which will in turn contaminate the tea with toxic and carcinogenic substances.

The main chemical substances in tea are essential oils, caffeine, and polyphenols (popularly and mistakenly known as tannins). The essential oils give us the aroma of the tea, the caffeine stimulates the central nervous system, and the polyphenols account for the antioxidant and anti-disease properties.

Figure 1. Picking tea at Phu Fa in Nan Province.

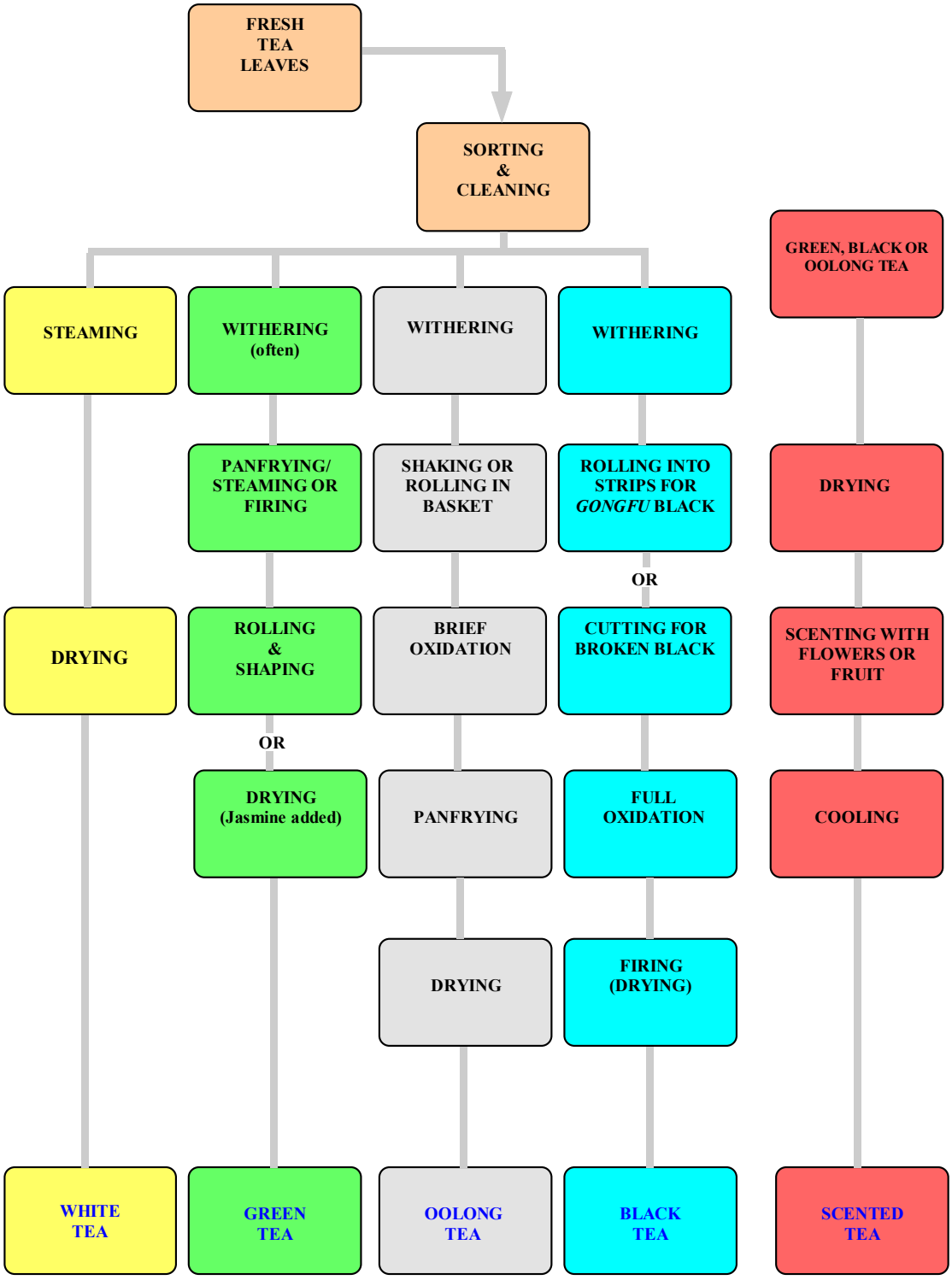

Figure 2. Steps in the Processing of Tea.

History of Tea in Thailand

With a long history of trade between the two countries, tea was undoubtedly first introduced from China. Overseas Chinese settled in the far South of Thailand around the trading ports, in Chonburi and Rayong and the capital at Ayuthaya, bringing with them their tea culture – particularly Oolong. Later immigrants were the backbone of the tin industry in the South. Today, the Chinese population is both integrated and very widespread. While still dominating the trading class, Chinese descendants are now involved in almost every field of endeavour, including governing the nation. Tea consumption is thus widespread and at every level of society, although it has diminished somewhat lately due to the pervasiveness of the Coca Cola culture.
The development of what is known today as Thai tea is unclear. Given that most recipes call for condensed milk, it could not predate the introduction of that product to the country, as it could not predate the introduction of crushed ice. Iced coffee, traditionally made from concentrate (*oliang*), was probably introduced around the same time. The development of Thai tea however, seems unrelated to the consumption of Oolong. Thai tea is black and preferred strong. It is not unlike the tea still consumed in Burma, although in Thailand it is preferred cold. It would be fair to assume that Thai tea (with its addition of milk) has its roots in Europe or America, rather than China. It was probably introduced during the time of Field Marshall Pibul Songkram, who seemed to favour Western habits as being civilized.

Thanks to the popularity of Thai restaurants abroad, Thai iced tea has become one of the first things foreigners discover when dining at a typical Thai restaurant. It is a native-grown red-leafed tea which is spiced with star anise seed. It is usually brewed strong and then blended with a rich swirl of evaporated milk

It should be noted that the consumption of tea as a food predates its consumption as an iced beverage in Thailand. Although now regarded as Thai, or at least Northern Thai, the origin of *miang* must be with the hill tribes, and they have probably been roaming the hills for centuries. Traditionally it was made by taking steamed tea leaves with salt, oil, garlic, pig fat and dried fish and fashioning them into balls, very similar to how the African's made their coffee balls [Cornell University]. The term *miang* has since become all-inclusive for delicacies wrapped in small bundles in leaves.

So the enjoyment of tea is not new to Thailand although it does not dominate the beverage market as in other parts of the world. More recently however, Thailand has suddenly discovered cold green tea, and with modern packaging and marketing, it has become the growth product of the beverage industry. Even Coca Cola is now producing and marketing a green tea beverage.

Thailand, although neither a major producer nor exporter, has been growing tea for over 60 years. The mountainous regions of North Thailand favour the cultivation of tea plants and the district of Doi Mae Salong is noted for growing quality Oolong tea. The growers are descendants of the Chinese Kuomintang (KMT) who were welcomed in northern Thailand as a buffer against the onslaught of Mao Zse Tung’s armies in southern China. A noted producer of Thai grown, **"**black**"** tea is the Raming Tea Company, which has a faithful following of consumers.

In1995, Taiwan introduced superior seedlings and provided training in methods to increase yield. Eventually the seedlings were produced in Thailand itself and distributed to a number of (KMT) villages [Tzu Chi Foundation, Bangkok].

Table 1. Tea production in Thailand 2004.

Province	Planted Area (*rai*)			Average Yield (kg/*rai*)	Total Product (tons)	Av. Price (Baht/kg)
	Bearing	Non-Bearing	Total			
Chiang Rai	39,653	7,130	46,783	515	20,404	25.70
Chiang Mai	20,020	45	20,065	432	8,646	5.88
Prae	2,600	0	2,600	1,850	4,810	5.00
Maehongson	841	14	855	1,574	1,323	34.33
Lampang	4,193	560	4,753	1,944	8,150	22.50
TOTAL	**67,307**	**7,749**	**75,056**	**644**	**43,333**	**20.33**

Source: Department of Agricultural Extension, Bangkok. 2004.
Note: 1 hectare = 6 *rai*. 1US$ = 40 Baht.

The Case for Green Tea

The first green tea was exported in 1611, when the Dutch East India Company established a factory on Japan's Hirado Island. Currently 2.5 million metric tons of tea leaves are produced each year throughout the world, with 20% produced as green tea, which is mainly consumed in Asia and in some parts of North Africa. Only recently has green tea become more widely available and consumed in the United States and Europe.

During manufacturing of green tea, preservation of the intact green leaf is of utmost importance. Green teas are not fully oxidized like black teas, or partially oxidized as oolongs. Instead, the tea leaves are plucked, steamed (the Japanese method) or dried on hot pans (the Chinese method), which removes the oxidizing enzymes, rolled and then dried. Rolling not only facilitates the drying of the leaves but also imparts to them their characteristic twist. The twist of the finished leaf determines the rate at which it will infuse when brewed. This process not only establishes the character of finished tea, but also shapes the finished leaf and provides the code by which the attributes of tea are released into the brew and in what proportions. This process yields a chemical composition in green tea similar to the fresh tea leaf. Green tea is processed within one to two days of harvesting.

Green tea has a high content of vitamins and minerals. It contains ascorbic acid (vitamin C) in amounts comparable to a lemon. Green tea also contains several B vitamins which are water soluble and quickly released into a cup of tea. Five cups of green tea a day will provide 5-10% of the daily requirement of riboflavin, niacin, folic acid and pantothenic acid. The same five cups of green tea also provide approximately 5% of the daily requirement of magnesium, 25% of potassium and 45% of the requirement for manganese. Green tea is also high in fluoride. A cup of green tea provides approximately 0.1 mg of fluoride, which is higher than usually found in fluorinated water. Fluoride is absorbed naturally into tea plants from soil and rain-

water, and varies from year to year, harvest to harvest and hill to hill … and among regions of the world.

Much research, epidemiological studies and clinical trials conducted around the world have concluded that green tea (black and oolong teas to a lesser extent) may reduce the risk of many chronic health problems. The naturally occurring chemical compounds in tea, called 'polyphenols,' are powerful antioxidants. The primary polyphenols found in tea are called 'catechins' which account for 30 to 40% of dry tea weight. Other polyphenols found in tea include flavanols, flavanol glycosides, flavandiols, phenolic acids and depsides. Polyphenols act as 'bodyguards', preventing damage caused by free radicals (damaging forms of oxygen) by combining chemically with the free radicals. Polyphenols give tea its characteristic astringent flavour. Polyphenols are chemically similar to tannins, however tannins are not present in tea. Scientific studies have shown very strong evidence that green tea (which contains high levels of polyphenols) may help lower blood pressure and therefore reduce the risk of strokes and heart disease. Further, green tea consumption is also linked with the prevention of many types of organ cancer including: lung, colon, oesophagus, mouth, stomach, small intestine, kidney, pancreas and mammary glands. Green tea may also prevent skin cancer, when used both topically and orally. It has also been linked with helping the liver to rid the body of toxins.

Epigallocatechin gallate (EGCG) is said to be the most powerful health component and makes up 5% of green tea, whereas green tea extract produced as a food additive has 32%. Teavigo, produced in China, claims to contain up to 93% EGCG. Physical separation is achieved through resin extraction.

Due to the discovery of these many health benefits, not only are more green teas appearing on store shelves, but also many new products containing green tea are being developed. Green tea may now be found as an ingredient in a wide range of products including beverages, confectionery, hair care products, body lotions and sunscreens.

Principle Chinese provinces producing green tea are Anhwei, Chekiang and Kiangsi and to a smaller extent, Fukien, Kwangtung and Hunan. China greens grow from June to December - the early teas are generally the best, however, many expensive greens are plucked in November and December. The principle green teas from China are; Moyunes, Tienkais, Fychows, Pingsueys, Hoochows, Wenchows, Kiukiangs and Foochows. Moyunes are considered the premium green tea in China and are divided into three classes.

The following market report on one green tea producer in Thailand gives a clear indication of the domestic trend, current market size and the potential:

"*Thai green tea and sushi restaurant firm Oishi Group said it expects 2005 sales to exceed 5 billion Baht (US$123 million) previously projected due to strong demand for green tea.*

Sales of the drink new to Thailand but already popular in Japan and Taiwan, rose strongly during marketing campaigns, company president Tan Passakornnatee said. "We've not revised our target, but we expect to beat that after sales of green tea rose 74% during the campaign," Tan said, referring to the March-May period compared

with the previous three months. His 2005 sales forecast was higher than that of 4.88 billion Baht by analysts polled by Reuters Estimates. Oishi had sales of 3.27 billion Baht last year.

Oishi, which means "delicious" is expected to make a net profit of 652 million Baht this year, up 34% on the year. The company, which earns more than half of its revenues from green tea, sold more than 30 million bottles of it per month during the first five months of this year, Tan said.

Oishi, which has a market share of 62%, planned to spend 250 million Baht on new machines this year to increase the production of green tea to 45 million bottles per month from about 30 million, Tan said. But the firm would continue to produce 20 million cartons of green tea per month, he added. Oishi also planned to launch new green tea products and open distribution outlets to maintain its market leadership, Tan said.

Overall sales of green tea in Thailand, where the appetite for luxury comestibles is growing, should double to 20 billion Baht over the next few years, he added". [Reuters – reported in TradeArabia. June 2005].

Against this backdrop, Sermsuk (bottlers of Pepsi) announced on 10 June that it would be developing new flavours and fruit juices, as it feels that these "have brighter potential than green tea for lack of dominant players". Coca Cola announced its entry into the green tea market in early June, joining Nestle, Tipco and Unilever.

Japan has established the World Green Tea Association which appears to have a clear majority of Japanese executives on the board. (http://www.o-ha.net/english/association/). Under the Ministers of Agriculture, ASEAN has a Tea Business Forum although it is not clear how active Thailand is in this. Indonesia has a Tea Association: indotea@indosat.net.id Vietnam, currently the seventh largest exporter, has a Tea Association and has now adopted a national trademark because the product "suffered from a lack of identity on the international market". [Vietnamnet Bridge, 10 February 2005].

It is clear that production of green tea, particularly for sale as a ready made beverage, is attracting the big players in Thailand. To obtain a clearer picture would require the Thai government to distinguish clearly between green and other teas in its statistics, how much has value-addition (i.e., sold as a beverage), how much is consumed locally and how much is exported. From there, an analysis needs to be made as to what particular advantages Thailand has for green tea production that will help it to grasp and retain the market.

The Potential of White Tea

Green tea may not be the only tea with powerful health benefits. According to researchers in the USA, white tea might have the strongest potential of all teas for fighting cancer, especially colon cancer.

Researchers speculate that the processing of tea determines its cancer fighting potential. Because white tea goes through the least amount of processing, it

theoretically has the most polyphenols (as some polyphenols are oxidized or destroyed during processing). These polyphenols have been linked to cancer prevention.

While experiments have been conducted on laboratory rats, more studies are needed in order to determine whether white tea protects humans against cancer.

Major Producers and Markets

China accounts for 18% of world exports, though most production is consumed internally. India accounts for 14% of exports and has 400,000 hectares under cultivation, mostly in Assam. Sri Lanka has 220,000 hectares under cultivation and accounts for 21% of world exports. Africa (Kenya, Malawi, Tanzania, Zimbabwe, South Africa), a more recent arrival on the tea cultivation scene, accounts for 25% of world exports, mostly used for blending. Indonesia accounts for 8% of world exports, with 128,000 hectares under cultivation (1994 figures) and Turkey exports a similar quantity. While Japan has always produced high quality green tea, very little is exported due to high production costs. Tea is also produced in Malaysia, Burma, Laos, Cambodia and Vietnam. Argentina has recently become a contender in the world market and Nepal is now exporting.

Traditionally, tea is packaged and sold as dry leaves. More recently, tea bags have become popular for their convenience and, thanks to processing advances, tea can now be found in either powdered or brick form. However, the habits for consuming tea vary from country to country and new products are constantly being developed. While such developments open up new markets, the producer must be conscious of these and develop the product accordingly.

One of the latest emerging trends in the tea market is **bubble tea**. This drink originated in Taiwan over 10 years ago and is also known as Tapioca Tea, Pearl Tea, Milk Tea, Booboo, Hen Zhu NIA Cha and variations on these names. The two main ingredients of this cold beverage are tapioca balls and milk tea. Several varieties exist and can include exotic fruit flavourings such as Papaya, Honeydew and Taro as well as ice cream. The "bubble" comes from the round, gummy tapioca balls that are boiled in the tea flavouring. In the past few years, Bubble Tea has become increasingly fashionable in areas such as New York, Los Angeles, Seattle and Vancouver where it is drunk with large colourful straws.

Chai, from India, is basically spiced milky tea and it is becoming increasingly popular all over the world. In the United States Chai has caught on and is being sold as 'Tea Latte', a popular alternative to its coffee namesake. It is generally made up of rich black tea, heavy milk, a combination of spices and some form of sweetener. In traditional Indian recipes the spices vary from region to region but the most common are cardamom, cinnamon, ginger, cloves and pepper.

More than 80% of all the tea consumed in the US is served as **iced tea**. It is now becoming more popular in the UK and iced tea in Europe is one of the fastest growing soft drink segments, with consumption tripling over the last ten years. Usually either Ceylon or China Keemun are favoured for iced tea.

Tea is sold in a variety of ways. It may be sold at auction in countries of origin. There are international auction centres in Mombassa in Kenya, Colombo in Sri Lanka and Limbe in Malawi. India has auction centres in the north and south. Indonesia sells tea in Jakarta. China sells her tea by numbered standards at commodity fairs at Guangzhou.

Tea prices are governed by quality, supply and demand. Tea brokers act as intermediaries and taste, value and bid on their client's behalf. Tea may also be sold from the tea garden by private sale or at offshore auction whilst en route to its destination.

Consumer research in Europe and North America shows that approximately 60% of tea drinkers do not order tea in restaurants because it is not properly prepared. The market potential for increased tea sales in these foodservice establishments is significant given that currently only about 11% of tea is consumed out-of-home.

Environmental Considerations

Tea, being a highland crop, will unavoidably be detrimental to the environment. Particularly vulnerable are forest and watershed areas. Thus careful planning and land classification is necessary before any major expansion of tea growing areas is contemplated.

Traditional *miang* plantations usually were smallholder lots covering land previously used for swidden or otherwise degraded, and often retained trees useful for shade or other purposes. They provided a settled form of agriculture for hill tribes as well as a cash crop. If tea cultivation is taken out of the hands of hill tribes, particularly by large holdings, then the hill tribes will have no alternative than to encroach on the little remaining forests and possibly return to opium cultivation. At the very least they would become a problem for state welfare.

One factor affecting the industry in Northern Thailand is the influence from Taiwan, mainly assisting Kuomintang settlers, but also direct investment in the industry itself. Oolong tea has been one of Taiwan’s major agricultural exports and it has been the cause of serious environmental damage in that country. Mudflows and landslides caused by deforestation are a frequent problem during the monsoon. Due to higher standards of living, Taiwan now imports more tea (in value terms) than it exports and thus agri-business concerns in Taiwan are looking for places where their tea can be grown more cheaply. There is every possibility that such environmental problems will also be exported.

Interventions for Agricultural Science

Tea is a perennial crop, except for a short period of dormancy which is restricted to some tea-growing areas, including parts of India, Argentina, China, Turkey and Iran, during which production is at a standstill. In the southern Indian tea growing area, bushes do not become dormant and plucking continues throughout the year. However, the crop harvested during different months varies and two distinct peaks are observed in the annual crop output curve. In the north Indian tea-growing regions, tea bushes remain dormant during the dry winter months and no tea is harvested during this time.

The length of the dormancy period increases progressively with increasing distance from the equator.

Tea bushes are typically planted in single or double hedges, with a density ranging from 10,000 bushes to 15,000 bushes per hectare. These saplings take five to seven years to mature into yielding tea bushes and, if well-cultivated, yield tea leaves for as long as 100 to 150 years, with higher productivity in the first 50 years.

Tea production is influenced by weather conditions. Unusual patterns can decrease production or affect the quality and taste of the tea leaf. In 1997, Kenyan tea plantations suffered a sharp decrease in production due to damage caused by El Nino. In 1999, northeast Indian plantations endured the country's worst drought in many decades, which caused a nationwide drop in production of 6% up to October 1999. However, favourable weather conditions in 1998 led to record crops in both India and Kenya.

Cultivation

In its wild state, tea grows best in regions that enjoy a warm, humid climate with a rainfall measuring at least 125 centimetres a year. Ideally, it likes deep, light, acidic and well-drained soil. It grows mainly between the tropic of Cancer and Capricorn, requiring a temperature ideally between 10 to 30 degrees centigrade.

Given these conditions, tea will grow in areas from sea level up to altitudes as high as 2,500 metres above sea level. Tea varies in flavour and characteristics according to the type of soil, altitude and climate of the area in which it is grown. For example, Indian Darjeeling thrives in the chilly 2,000 metre-plus elevations of the Himalayan foothills. The cooler temperatures and thinner air contribute to leaves that produce superior bouquets and much richer flavours. The tea estate is where the flavour potential of the tea will be generated, and so great care and attention is taken to insure that the best possible growing conditions are created. This means in some cases planting trees to generate shade, or planting windbreaks, to prevent damage from strong winds. The way tea is processed also affects the flavour and characteristics, as does the blending of different teas from different regions.

The wild tea plant can develop into a tree five to eight metres high. However, under cultivation, *Camellia sinensis* is kept to a height of approximately one metre for easy plucking. For an interesting paper regarding conventional wisdom on the height and size of bushes see: http://www.actahort.org/books/153/153_40.htm

A recent report by the Sri Lanka Tea Research Institute shows that by applying small amounts of fertilizer daily (300 times/year) and reducing nitrogen to 180kg/ha/year, production dramatically increases. This impressive result was achieved in a tea plantation with high rainfall and infertile eroded soils. While these findings cannot be achieved in fertile soils, serious consideration and study in other tea locations should be given to the fact that the highest yield increase was reached with only 180kg of nitrogen.

Experiments have been conducted in Africa combining drip irrigation and fertilizers. Results showed very dense rootlets concentrated under the dripper. It was concluded that genetically coded structural roots will continue to grow away and down, and will

survive the drier month. It was also found that soil in the tea environment (800 mm) never dried off totally and that as long as the aboveground canopy is alive, water will be transported from the wetter to the drier parts of the root system. [Netafim. May 2004].

Tea Estates

Tea is an example of a crop which is grown on special farms called estates or smallholdings. A smallholding is privately owned and can be as small as 0.5 hectares or can cover several hectares. In various tea-producing countries, where tea is grown on smallholdings, co-operatives are formed to build a tea-processing factory central to a group of smallholders. The owners of the smallholdings sell their plucked leaf to the factory for processing.

Tea Picking and Harvesting

In most tea-producing countries, the labour-intensive method of picking, drying, crushing and oxidizing tea has been used for centuries. The plucked leaves are collected in a basket or bag carried on the back of the plucker and when this is full it is taken to a collection point where the plucked leaf is weighed. It is then taken to the factory for processing, or "making", as tea manufacture is known in the tea trade.

On average, 1,000 kilograms of green leaf are required to make just over 200 kilograms of black tea. The productivity of a tea plantation is measured by its yield of black tea per annum per hectare planted. A good yield is between 1,000 to 2,500 kilograms per hectare for hand picked plantations and 3,000 to 4,000 kilograms per hectare for mechanically harvested plantations.

Although leaves for green, oolong and black tea can be produced from the same bush, today’s tea growers tend to specialise in one variety.

Project work has been undertaken in Indonesia, with assistance and advice from ACIAR in Australia, and has opened the opportunity for Indonesia to replant very large areas of tea. The program was introduced as smallholders had half the productivity of good estates and also because many of the varieties planted were susceptible to blister blight. The project has shown how to produce large numbers of the most suitable varieties from somaclonal embryos that grow into vigorous, fast-growing plantlets with a strong taproot. According to the chief breeder at the Tea Research Institute in Indonesia, these embryos will provide the best material for the future and will benefit large numbers of Indonesia’s smallholder tea producers.

Possible Interventions for Food Technology and Engineering

One of the identified problems in Thailand is processing equipment. This requires improvement to existing equipment, as well as the possibility for new design and

innovation. Both need to meet GMP standards, as well as incorporating energy efficiency and environmental compatibility.

For Thailand, it needs to be determined if the process for producing green tea beverage is undertaken by the leaf processors, or whether the leaves are simply sold to

the beverage producers. If it is the latter, then the processes for both need to be examined.

Processing

On arrival at the factory, the plucked leaf is weighed and assessed for quality before being put in withering bins attached to huge air vents. The moisture in the leaf evaporates in the warm air leaving the leaves flaccid. This process can take between 10 to 16 hours, depending on the wetness of the leaf. Some factories will gently hasten the process with the aid of warm air fans.

The withered leaf is broken down by machine so that the natural juices, or enzymes, are released and on contact with the air will oxidise. The shredded leaves, called *dhool*, are then crushed and fed through the CTC (cut, tear and curl) or Rotovane machine. Its sharp teeth cut the leaf then tear it to release the juices that contain the tea flavour.

Orthodox. This is the traditional process of manufacturing tea. It begins with withering freshly picked tea leaves which lose approximately half their moisture within 12 to 18 hours. At the end of this process, the leaf is flaccid. The flaccid leaves then enter a process known as "rolling" which ruptures the leaf cells to release enzymes, and then twists or curls the leaf. Thereafter, to stop oxidation, the leaf is exposed to hot air by passing it through a chamber with perforated moving trays in a process known as "firing". This chamber is known as the drier. This dries the leaf and turns it a black colour. After the fired leaf is cooled, it is sorted by sieves.

CTC. This process is known as "CTC" because the tea leaf is crushed, torn and curled. The process is similar to orthodox tea making. In CTC manufacture, after rolling, the tea leaves are passed through a machine, known as the CTC machine, where the leaves are cut or crushed to a greatly reduced size and most of their cells are ruptured. This intensifies the process of oxidation.

Oxidation

The broken leaf is laid out either on trays or in troughs in a cool, humid atmosphere for up to two hours to oxidise. The trays are gently turned every so often throughout the period until all the leaves turn a golden russet colour and oxidation is complete. This remains one of the most challenging stages of production.

Drying

After oxidation, the leaf is dried or fired. This is done by passing the broken oxidized leaf slowly through hot air chambers where all the moisture is evaporated and the leaf

turns a dark brown or black. It is at this stage that the aroma changes from that of a

pungent plant to the familiar earthy tea perfume. The black tea is ejected from the hot chamber into chests. Next it is sorted into grades, or leaf particle sizes, by being passed through a series of wire mesh sifts of varying sizes into containers. It is then weighed and packed into chests or "bags" for loading onto pallets. The bigger curly leaves are used for loose-leaf packet tea while the finer particles are used for tea bags.

Factory tea-tasters will taste the finished "make" to ensure that no mistakes have been made during the manufacture or that the tea has not been tainted by anything within the factory. After each make the tea factory is washed from top to bottom to ensure that the character of the completed make does not transmit to the next make of tea.

Black tea processing uses as raw material the young shoot of the tea plant, comprising the terminal bud and the two adjacent leaves. This is known as the "flush". The "flush" is processed in distinct stages: withering, rolling, oxidizing, firing (drying) and grading. Each stage involves characteristic changes in the physical and biochemical composition of the leaves and the cumulative effects of these changes are ultimately reflected in the quality of the finished black tea product.

Marketing

World tea production from 1990-1998 grew at a yearly rate of 1.81% and consumption kept pace at a slightly higher growth rate of 2.05% per annum. World tea production has been dominated by India where output peaked at over 870,000 tonnes in 1998. The second largest producer is China with its highest output also recorded in 1998 when production reached 665,000 tonnes. Kenya follows at a distant third at 294,200 tonnes, Sri Lanka at 280,100 tonnes. Indonesia, Argentina and Bangladesh follow as fifth, sixth and seventh respectively. [FAO].

In 1998, global tea production increased nearly 9% to reach its highest level ever. The World output reached 2.963 million metric tons, surpassing the previous record 2.724 million tons in 1997. Key producers all brought in record-setting crops during 1998: Indian production was 870,405 tons; Sri Lanka's was 280,674 tons; and Kenya's was 294,165 tons. Other 1998 production figures included the following: China, 665,034 metric tons; Indonesia, 166,121 tons; Turkey, 177,838 tons; Japan, 82,609 tons; Iran, 60,000 tons; Bangladesh, 55,700 tons; Argentina, 50,000 tons; Vietnam, 42,000 tons; Malawi, 40,360 tons; Uganda, 26,422 tons; Tanzania, 24,333 tons; Taiwan, 22,641 tons; Zimbabwe, 17,755 tons; Rwanda, 14,850 tons; and South Africa, 10,845 tons. [ITC].

More recent detailed figures on production, marketing and consumption are available, but expensive. World tea production in 2004 reached 3.2 million tonnes. The FAO Composite Price averaged $US 1.65 per Kg in 2004, about 9% higher than 2003. At a time when prices are usually low, the continued firm prices reflect a possible crop shortage in 2005. [FAO. May 2005]. Thailand is a member of the FAO Intergovernmental Group on Tea and regularly attends the sessions.

Appendix A lists the standards currently applicable for tea production.

Conclusion

Tea production and marketing is a growth area for Thailand. While the fad for bottled cold tea has diminished somewhat, tea retains an important role in the beverage sector. For Thailand to become a major player in world markets, several factors are necessary. The first is government attitude and support for the industry, which could be greatly enhanced if all involved formed some sort of association. The second is the possible intervention for biotechnology to improve yield and quality for smallholders, similar to what Indonesia has undertaken. Finally, as more evidence comes forward

regarding the health benefits of tea, innovative ideas and products should be tested and introduced, according to market demands. The possibility of soaps for spas is but one example.

References and Further Reading

http://www.teahealth.co.uk/tea_healthcentre_01a.html

http://www.tea.ca/media_healthresearch.asp?section=healthpro

http://www.fao.org/unfao/bodies/ccp/Ccp62/W5955E.htm

See also, WTO Committee on Technical Barriers to Trade: Notification: Thailand: Tea:
http://www.ipfsaph.org/servlet/CDSServlet?status=ND1jdGh0dHB3d3dmYW9vcmdhb3NpcGZzYXBoaW5mb3JtYXRpb25zb3VyY2V3dG8uV1RPVEJUTkYwMTA0MjMmNj1lbiYzMz1mb3JtYWxfdGV4dCYzNz1pbmZv

APPENDIX A

Standards

ISO 1572:1980	Tea: Preparation of ground sample of known dry matter content.
ISO 1573:1980	Tea: Determination of loss in mass at 103^{O}C.
ISO 1575:1987	Tea: Determination of total ash.
ISO 1576:1988	Tea: Determination of water-soluble ash and water-insoluble ash.
ISO 1577:1987	Tea: Determination of acid-insoluble ash.
ISO 1578:1975	Tea: Determination of alkalinity of water-soluble ash.
ISO 1839:1980	Tea: Sampling.
ISO 3103:1980	Tea: Preparation of liquor for use in sensory tests.
ISO 3720:1986	Black Tea: Definition and basic requirements.
ISO 3720:1986/Cor 1:1992	
ISO 3720:1986/Cor 2:2004	
ISO 6078:1982	Black Tea: Vocabulary.
ISO 6079:1990	Instant Tea in solid form: Specification.
ISO 6770:1982	Instant Tea: Determination of free-flow and compacted bulk densities.

ISO 7513:1990	Instant Tea in solid form: Determination of moisture content (loss in mass at $103^{O}C$).
ISO 7514:1990	Instant Tea in solid form: Determination of total ash.
ISO 7516:1984	Instant Tea in solid form: Sampling.
ISO 9768:1994	Tea: Determination of water extract.
ISO 9768:1994/Cor 1:1998	
ISO 9884-1:1994	Tea Sacks: Specification: Part1: Reference sack for palletised and containerised transport of tea.
ISO 9884-2:1999	Tea Sacks: Specification: Part2: Performance specification for sacks for palletised and containerised transport of tea.
ISO 10727:2002	Tea and instant tea in solid form: Determination of caffeine content: Method using high-performance liquid chromatography.
ISO 11286:2004	Tea: Classification of grades by particle size analysis.
ISO 14502-1:2005	Determination of substances characteristic of green and black tea: Part1: Content of total polyphenols in tea: Colorimetric method using Folin-Ciocalteu reagent.
ISO 14502-2:2005	Determination of substances characteristic of green and black tea: Part2: Content of catechins in green tea: Method using high-performance liquid chromatography.
ISO 15598:1999	Tea: Determination of crude fibre content.