TEA

1. Production and Use

1.1 Introduction

The origin of tea is lost in ancient history, although legend dates it at about 2700 BC (Woodward, 1980). The first generally accepted reference to tea is found in a Chinese dictionary from 350 AD which stated that the beverage was used as a medicine for various ills (Schapira *et al.*, 1975). Tea achieved popularity in the west only during the late seventeenth and eighteenth centuries, although it was brought to Europe in 1559 (Wickremasinghe, 1978). The first public sale of tea in England was held in 1657. The beverage's popularity grew, and its trade became an economic mainstay. Today, tea is arguably the most popular beverage in the world (Graham, 1984).

Black and green tea are the two main types, defined by their respective manufacturing techniques. Green tea is consumed mostly in Japan, China, North Africa and the Middle East; the remainder of the world uses black tea. Oolong tea, found in some regions of China, is an intermediate variant between black and green tea (Graham, 1983). Black and green teas lightly flavoured with other botanicals are sometimes seen; these include jasmine tea, scented with jasmine blossoms, and Earl Grey tea, flavoured with bergamot, a type of citrus fruit (Graham, 1984).

1.2 Production processes

A general description of tea manufacture and terms used is provided by Eden (1976) and, more briefly, by Graham (1984) and by Millin (1987).

(*a*) *Botany and culture*

Tea was first cultivated in China and then in Japan. With the opening of ocean routes to the east by European traders during the fifteenth, sixteenth and seventeenth centuries, commercial cultivation gradually expanded to Indonesia and then to the Indian subcontinent, including Sri Lanka. Tea is now grown

commercially in tropical and subtropical regions of Asia, Africa and South America. Major exporting countries include Argentina, China, India, Kenya and Sri Lanka (Forrest, 1985).

All varieties and cultivars of tea belong to a single species, *Camellia sinensis* (L.) O. Kuntze (Cloughley, 1983), formerly called *Thea sinensis* (Graham, 1984). The plant is a tender evergreen that can grow to heights of 12-14 m (Forrest, 1985). The bushes are usually kept about 1 m tall by pruning and periodic harvesting of new growth, called flush. Flush is used for the manufacture of finished tea (Graham, 1984).

Throughout many of the world's tea growing regions, harvesting is done by hand as it has been for centuries. Mechanical harvesting is practised to some extent; however, uniformity and, therefore, quality are considered to be superior with the precise selection of leaf that is achievable only by hand selection (Graham, 1984; Forrest, 1985).

(*b*) *Manufacture*

Following harvest, fresh tea flush is subjected to a series of treatment steps that result in the manufacture of either black, Oolong or green tea. Black tea results from promoting enzymic oxidation of fresh leaves; the process was originally called 'fermentation' but does not involve microbial action; for the production of green tea 'fermentation' is prevented. The third type, Oolong, is produced by short fermentation (Graham, 1984).

(i) *Black tea*

Withering: After transport to the tea factory, freshly harvested leaves are spread in layers on trays and belts for up to 18 h in order to reduce the initial moisture content to approximately 60% of the leaf weight (Graham, 1983). Warm or ambient air may be circulated through the beds of tea leaves depending on local climatic conditions. A uniform moisture distribution is dependent on the uniformity of the flush and is important in maintaining the quality of the finished tea. Chemical changes, including an increase in caffeine content, begin during this step (Cloughley, 1983).

Rolling: The leaves are crushed and macerated, partially destroying cell structure, to allow enzymic oxidation of the flavanols in the presence of oxygen from the atmosphere. Orthodox rolling involves use of traditional devices that impart a characteristic curl to the leaf. Other types of maceration equipment are now becoming popular, for example, crush, tear, curl (CTC) is gradually replacing orthodox processing in some growing regions (Graham, 1983).

'Fermentation': During 'fermentation', tea undergoes significant compositional changes leading to the characteristic colour and flavour of black tea

(Sanderson, 1972). 'Fermentation' actually begins during rolling when endogenous enzymes are freed to comingle with other leaf components, primarily flavanols. This enzymatically catalysed aerobic oxidation and subsequent reactions constitute the 'fermentation' process. After rolling, the tea is spread in layers to optimize temperature, moisture and air circulation. The time for which the macerated leaf is allowed to ferment varies according to temperature and other local conditions but ranges from 45 min to 3 h. During this step, the tea begins to develop its characteristic aroma and copper-coloured appearance. Duration is judged subjectively and the reaction is stopped by the next step in manufacture (Graham, 1983). Some caffeine is lost during 'fermentation' (Cloughley, 1983).

Firing: Passing the tea on trays through hot air driers halts the enzymic fermentation step. Moisture content is reduced to 3% in about 20 min. During firing, nonenzymic chemical changes, resulting in further flavour and aroma development, continue. The tea takes on the black colour characteristic of black tea (Graham, 1983). Small amounts of caffeine are lost through sublimation (Cloughley, 1983).

Grading: The last step is to sort the black tea into appropriate grades. The dried leaves are passed through a series of screens with varying mesh sizes to yield tea corresponding to particular grades such as Orange Pekoe, Pekoe, broken Orange Pekoe, fannings and dust. Traditionally, bulk tea has been shipped in aluminium foil-lined plywood chests (Millin, 1987) holding 45-60 kg, depending on the tea's density (Graham, 1983). More recently, tea 'sacks', which are also foil-lined, have begun to replace the chests.

Specification: The International Organization for Standardization (ISO) (1981) has established a standard for black tea (ISO 3720-1981), which includes the following specifications:

"*Definition*: Tea derived solely and exclusively, and produced by acceptable processes, notably 'fermentation' and drying, from the leaves, buds and tender stems of varieties of the species *Camellia sinensis* (Linnaeus) O. Kuntze known to be suitable for making tea for consumption as a beverage.

"*General requirements*: The tea shall be clean and reasonably free from extraneous matter.

"*Chemical requirements*: (1) The tea shall comply with the requirements specified in Table 1, in which all the figures given are calculated on the basis of the material oven-dried to constant mass at 103 ± 2°C.

"Table 1. Chemical requirements for black tea

Characteristic	Requirement	Test method
Water extract, % (w/w) minimum	32	ISO 1574
Total ash, % (w/w)		
maximum	8	ISO 1575
minimum	4	
Water-soluble ash, as percentage of total ash, minimum	45	ISO 1576
Alkalinity of water-soluble ash (as KOH), % (w/w)		
minimum	1.0[a]	ISO 1578
maximum	3.0	
Acid-insoluble ash, % (w/w) maximum	1.0	ISO 1577
Crude fibre, % (w/w) maximum	16.5	Annex

[a] When the alkalinity of water-soluble ash is expressed in terms of milliequivalents per 100 g of ground sample, the limits are: minimum, 17.8; maximum, 53.6.

"(2) No limit is specified for the 'moisture' content of the tea. If desired, the actual loss in mass at 103°C of the sample under test may be determined and the result recorded in the test report. The determination shall be carried out by the method described in ISO 1573."

(ii) *Green tea*

Green tea is made from the same species as black tea, although the varieties used are suited to the specific climatic conditions prevailing in the growing region and local taste preferences. Green tea is not allowed to ferment. Harvesting is similar to that for black tea, but the fresh leaves are quickly subjected to heat in order to inactivate enzymes, thus preventing any oxidative fermentation from occurring. This is accomplished by either steaming the fresh leaves (Japanese type) or roasting in pans with dry heat (Chinese type) (Yamanishi, 1986). Prior to final drying, the leaves are pressed and rolled, which develops their characteristic shape and sizes. After drying, the leaf fragments are sorted into various grades. International standards have not been finalized for green tea (Graham, 1984).

(iii) *Oolong tea*

Oolong teas are only partially oxidized and retain a considerable amount of the original polyphenolic material. Manufacture is usually a cottage industry; the teas are prepared by a series of withering, gentle rolling and drying steps, which vary greatly from facility to facility. Sun drying is often utilized as the first step. The

appearance of the leaf is considered an important aspect of quality, and a significant amount of hand labour is often utilized. The colour of Oolong tea is intermediate between that of green and black tea (Graham, 1984).

(iv) *Instant tea*

Instant tea is used almost entirely to prepare iced tea. It is manufactured by a fairly exhaustive extraction of black tea with hot water. After separation of leaf matter from the extract, the latter is usually stripped of volatile substances (aroma) and concentrated. Drying of such a concentrate without further processing would result in a product incompletely soluble in cold water, so the extract is precooled to precipitate cold water-insoluble fractions, known as 'cream'. These may be processed to improve solubility and then added to the main extract. The preserved aroma fraction is added back to the total extract concentrate before spray or freeze drying (Graham, 1984).

In the USA approximately 15% of tea is used in the instant form. Production in 1981 was about 6000 tonnes; Kenya, India and Sri Lanka together manufactured about 1000 tonnes, much of which was exported to the USA (Graham, 1984).

(v) *Decaffeinated tea*

The most prevalent process for decaffeinating tea is extraction using supercritical carbon dioxide as the solvent. Conditions of temperature and pressure are chosen to favour the selective extraction of caffeine. Carbon dioxide is removed by allowing it to vapourize (Graham, 1984).

1.3 Preparation of tea beverage

(*a*) *Traditional*

Tea beverage is prepared by steeping tea leaves in water at 90-100°C in teapots or cups. Additional hot water may be added to residual leaf in teapots to produce more but often weaker beverage. In Japan, different varieties of green tea are steeped in water at the temperature considered appropriate for the tea used.

(*b*) *Tea bags*

Tea is confined in porous bags chosen to retain solids but allow free diffusion of water and beverage without imparting taste to the tea. In the USA, tea bags now account for well over 95% of home use. Their use is increasing throughout the world.

(*c*) *Brick tea*

In China, Outer Mongolia and the USSR, tea is sometimes compressed into bricks, pieces of which are used to prepare the infusion (Graham, 1984).

(*d*) *Iced tea*

This beverage may be prepared by cooling traditionally brewed tea, but it is sometimes prepared by the prolonged (8-24 h) steeping of tea at room temperature or in chilled water. Cold water-soluble instant teas, which may be sweetened and flavoured, are also used. Instant tea products are usually used at levels of 0.6-1.0 g of tea solids per 100 ml water. Iced tea beverage is also available in canned form.

(*e*) *Tea-gruel*

Tea leaves packed in a cotton pouch are boiled in water in an iron pan for several minutes. Washed or unwashed rice is then added and the mixture is reboiled. The product is usually eaten burning hot (Anon., 1974).

1.4 Production, trade and consumption

(*a*) *Production*

World production of manufactured tea in 1988 was nearly 2.5 million tonnes (Table 2). Four of the top five producing areas are in Asia. Green tea comprises about 21% of the total (International Tea Committee, 1989).

Table 2. World tea production in 1983-88 (in thousand tonnes)[a]

Continent or country	1983	1984	1985	1986	1987	1988
Asia (including Oceania)	1630.3	1748.0	1820.3	1817.0	1921.6	2026.5
Africa	224.9	236.1	271.8	260.3	263.9	282.3
USSR	145.6	151.1	152.1	146.6	120.0	120.0
South America	53.1	57.6	44.6	55.9	50.0	50.0
Total	2054.0	2192.8	2288.8	2279.8	2355.5	2478.8

[a]From International Tea Committee (1989)

Eight countries account for 86% of world production (Table 3); six of these eight account for 95% of green tea production. Virtually all tea produced in Japan and about 60% of that produced in China is green tea. India is the largest tea producer, nearly all of which is black tea.

Table 3. Tea production by country in 1988 (in thousand tonnes)[a]

Country	All tea	Green tea
India	701.1	8.0
China	545.4	338.5
Sri Lanka	228.2	1.2
Kenya	164.0	-
Turkey	153.2	-
Indonesia	135.6	30.0
USSR	120.0	24.0
Japan	89.8	89.8
Other	341.6	28.1

[a]From International Tea Committee (1989)

(*b*) *Exports*

About 40% of total tea production is exported, and five countries account for over 80% of these exports (Table 4). Of the eight most important producing countries, China is the only significant exporter of green tea. In Japan, Turkey and the USSR, nearly all the production is consumed within the country.

Table 4. Tea exports by country in 1988 (in thousand tonnes)[a]

Country	All tea	Green tea
India	221.5	2.0
Sri Lanka	219.7	1.3
China	198.3	78.6
Kenya	138.2	-
Indonesia	92.7	0.1
Other	183.1	12.5

[a]From International Tea Committee (1989)

(*c*) *Imports*

Total tea imports (adjusted for re-export) in 1988 were approximately 1030 thousand tonnes. The 15 leading importing countries in 1988 accounted for 80% of all imports. Imports over the last six years from these countries are shown in Table 5.

Table 5. Tea imports for consumption by country in 1983-88 (in thousand tonnes)[a]

Country	1983	1984	1985	1986	1987	1988
UK	155.2	184.2	155.4	171.1	142.6	162.7
USSR	55.8	70.0	95.8	109.9	134.8	140.0
Pakistan	86.7	85.7	89.1	84.8	90.1	85.5
USA	77.1	88.2	79.1	89.5	77.3	90.1
Egypt	65.5	75.0	76.2	72.9	64.9	76.4
Iran	27.4	29.1	32.6	25.5	28.4	40.3
Iraq	37.8	45.5	34.6	44.7	41.8	57.7
Poland	25.9	25.5	34.7	29.9	32.1	33.6
Japan	12.0	15.6	22.9	26.3	26.3	27.3
Morocco	16.6	22.6	22.3	20.4	23.4	30.0
Saudi Arabia	18.0	20.5	20.6	17.6	19.0	19.0
Australia	21.8	20.6	20.7	20.6	18.2	19.4
Germany, Federal Republic of	14.1	17.1	15.5	15.5	15.2	13.6
Canada	17.5	18.4	15.7	17.5	14.2	14.1
Sudan	12.9	10.7	14.0	11.1	13.0	13.0

[a]From International Tea Committee (1989)

(*d*) *Consumption*

Consumption data based on import, export and production statistics provide a sound estimate for economic purposes; however, determination of actual human consumption or ingestion must take into account the methods of beverage preparation and varying levels of extraction of tea leaves into finished beverages. In addition to the nature of the manufactured leaf, brewing variables, such as leaf to water ratio, temperature and time, all affect the amount of solid extracted.

The estimates of the International Tea Committee of actual consumption take into account imports, exports and, when possible, locally grown tea. Tables 6 and 7 show total and per-caput consumption, respectively.

Table 6. Total average tea consumption by country (in thousand tonnes)[a]

Country	Consumption		Country or region	Consumption	
	1984-86	1985-87		1984-86	1985-87
India	415.10	430.00	Ireland	10.77	10.95
China	~ 350.00 (1988)		Netherlands	9.34	9.51
USSR	236.35	NA	Hong Kong	9.22	9.14
UK	166.97	160.03	France	9.21	9.45
Turkey	130.81	139.42	New Zealand	5.76	5.61
Japan	113.49	120.28	Algeria	5.18	4.90
Pakistan	86.56	88.02	Kuwait	4.37	4.16
USA	85.61	81.97	Jordan	3.92	4.07
Egypt	74.70	73.03	Tanzania, United Republic of	4.39	4.80
Iran	50.20	NA			
Iraq	43.20	41.40	Italy	3.43	3.55
Poland	30.06	32.25	Sweden	2.98	2.99
Sri Lanka	22.70	23.00	German Democratic Republic	2.72	2.60
Morocco	21.75	22.03			
South Africa	20.96	20.23	Denmark	2.36	2.30
Australia	20.64	19.87	Czechoslovakia	2.25	2.20
Saudi Arabia	19.54	19.05	Switzerland	1.89	1.80
Canada	17.22	15.79	Belgium/Luxembourg	1.36	1.34
Kenya	16.36	17.35	Austria	1.23	1.15
Germany, Federal Republic of	16.03	15.40	Qatar	1.16	0.99
			Norway	0.87	0.93
Syria	14.72	13.83	Finland	0.85	0.94
Tunisia	13.10	13.56	Bahrain	0.64	0.62
Sudan	11.89	12.68	Thailand	0.55	0.54
Afghanistan	11.33	NA	Greece	0.30	NA
Chile	11.01	11.43	Portugal	0.22	NA
			Spain	0.71	NA

[a] From International Tea Committee (1989)
NA, not available

Table 7. Average tea consumption *per caput*[a]

Country or region	Amount (kg)		Country or region	Amount (kg)	
	1984-86	1985-87		1984-86	1985-87
Qatar	3.74	3.21	Afghanistan	0.63	NA
Ireland	3.03	3.09	South Africa	0.56	0.53
United Kingdon	2.94	2.81	Sudan	0.55	0.56
Iraq	2.72	2.51	India	0.55	0.55
Turkey	2.65	2.72	Denmark	0.46	0.45
Kuwait	2.55	2.23	Sweden	0.36	0.35
Tunisia	1.81	1.82	USA	0.36	0.34
New Zealand	1.77	1.71	China	~ 0.35 (1988)	
Hong Kong	1.69	1.63	Switzerland	0.29	0.27
Saudi Arabia	1.69	1.40	Germany, Federal Republic of	0.26	0.25
Egypt	1.54	1.44			
Bahrain	1.52	1.45	Algeria	0.24	0.22
Sri Lanka	1.43	1.41	Norway	0.21	0.22
Syria	1.43	1.26	Tanzania, United Republic of	0.20	0.21
Australia	1.31	1.22			
Jordan	1.12	1.12	Finland	0.17	0.19
Iran	1.05	NA	France	0.17	0.17
Morocco	0.99	0.97	German Democratic Republic	0.16	0.16
Japan	0.94	0.99			
Chile	0.91	0.93	Austria	0.16	0.15
Pakistan	0.90	0.86	Czechoslovakia	0.14	0.14
USSR	0.85	NA	Belgium/Luxembourg	0.13	0.13
Poland	0.81	0.86	Italy	0.06	0.06
Kenya	0.80	0.76	Portugal	0.02	NA
Canada	0.68	0.62	Spain	0.02	NA
Netherlands	0.65	0.65	Thailand	0.01	0.01

[a] From International Tea Committee (1989)
NA, not available