CHEMISTRY AND HEALTH PROMOTING PROPERTIES OF TEA POLYPHENOLS FOR LIFE SUPPORTING SYSTEMS

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Contents

Summary

Chinese legend claimed that the tea consumption dates goes back to 2737 B.C. Tea, processed and prepared in variety forms is the most widely consumed ancient beverage in the world and tea polyphenols including green and black tea are reportedly attributed with many health-promoting properties to the subjects. In addition to increased availability of wide varieties of tea, improved brewing methods, focused research on tea polyphenols for health promotion and life supporting systems had changed the way people perceive tea. It acts as an effective natural antioxidant owing to its free radical scavenging and metal chelating ability. Due to which tea and its polyphenols are reported to be active against oxidative stress, aging, obesity, inflammation, clastogenesis and several types of cancer with mechanisms involved. Through antioxidant function, tea blocks activation pathways of mutagens, suppressing transcription of enzymes involved, caused by oxidative stress or presence of pro-mutagens thereby reducing DNA damage and mutagenesis. Studies indicate that tea may have a role in preventing cardiovascular diseases as it inhibited low-density lipoprotein (LDL) peroxidation and suppression of fatty acid synthase etc. Besides, tea and its constituents possess beneficial effects on the gastrointestinal tract; it affects motility, absorption, microflora etc. By influencing the hormonal balance and antioxidant function, tea improves bone mineral density. It also has antiviral and antimicrobial activity due to its enzyme inhibiting and receptor blocking properties. Protective role in cancers of gastrointestinal tract, liver, and prostate is confirmed. Tea polyphenols significantly inhibited the formation of acrylamide adducts with hepatic DNA in mice through reduction of protamine adducts. Tea extract was found to inhibit aflatoxin (B_1, B_2, G_1 and G_2) production in liquid broth. Treatment with black tea to diabetic (induced by STZ) rats was found to decrease formation of diabetic cataracts.

Extracts of tea were known to inhibit the growth of various bacteria causing diseases. Tea polyphenols exhibited protection against intestinal disorders as shown by the influence of tea on propagation of *Bifidobacterium* and *Clostridium.*

A black tea-blended with beet tea beverage was claimed to improve appetite, possessed expectorant qualities, suppressed fever, prevented dental caries, allergy and bone diseases and possessed deodorant and antimicrobial properties. The reports indicate that there is wide scope for further research on the efficient use of green and black tea active conserves / isolates/polyphenols to reap the number of health promoting benefits.

1. Introduction

Tea continues to expand as an emerging health beverage while populations are accepting for its health promoting properties besides rich aroma and taste. The advances in brewing methods and equipments attracted people to tea with changed perception. Green tea extracts are being widely used in food products due to their health-promoting properties. Green tea catechins, especially epigallocatechin gallate (EGCG), had been linked with a number of health benefits. Incorporation of EGCG into tofu represents an alternative means of enhancing both intake of EGCG and its health promoting effects. Fortification of firm and silken tofu with EGCG is reported. Black tea polyphenol extract is reported to prevent diet-induced obesity *in vitro* and *in vivo*. Potential health benefits associated with consumption of tea are reported and they include- health promoting compounds found in different types of tea; effects of processing on the catechin and theaflavin (TF) contents of tea.

1.1. Origin and History

Over 5000 (~2737 B.C.) years ago, Shen Nong, an emperor of China, on a summer day suggested a hygiene precaution and his servants began to boil potable water for safety. Dried leaves from the near by tree fell into the boiling water and got infused. A brown liquid was prepared. The curious monarch took a sip of the brew and was surprised by its flavor and restorative properties. Thus a legendary beverage tea was discovered. In another variant, *Gautama Buddha* is the one to have discovered tea when some leaves fallen in his boiling water. Legends apart it is certain that tea has played a significant role in Asian culture for centuries.

It was by the1600, through Europe and Americas' colonies tea got popularity. In 1690, Kaempfer, a German medical doctor cum botanist named the bush Thea. In 1753, the famed botanist Linne gave the name of *Camellia sinensis* changing its original name. In 1958, a British botanist Sealy classified all plants in genus *Camellia* and tea was given the name it has today. Based on differences in morphology between *Camellia sinensis* var. *assamica* and *Camellia sinensis* var. *sinensis*, botanists stated for a dual botanical origin of tea. *Camellia sinensis* var. *assamica* is native to the area from Yunnan province, China to the northern region of Myanmar and the state of Assam in India. *Camellia sinensis* var. *sinensis* is native to eastern and southeastern China. Today the bush tea is known as *Camellia sinensis* (L.) O.Kuntze of which there are two varieties: var.*sinensis* and var.*assamica.*

The first credible documentary reference on tea was made in 59 B.C. The ‘Ch'a Ching’ was written by Lu Yu, who described the botany, cultivation and processing of tea, etc., in details. Tea Classics or tea Sutra has been the bible for people involved with tea ever since.

The British had initiated and established tea cultivation in the northeastern parts of India and spread to South India during the First World War years and later to Sri Lanka. Many features of tea cultivation and processing were standardized and mechanization was undertaken to handle ever-increasing crop to meet global supplies. Green tea was improved to manufacture black tea, which enhanced shelf life of tea and allowed tea to be transported.

Darjeeling tea is grown in the foothills of the Himalayas and is accepted among the best teas of the world. Assam teas are known for their malty liquors and promoted as the milk teas and a process called CTC (Crush, tear and curl) was established to handle the huge bulk of the crop harvested during rainy season. Indian teas came to be known world wide as milk teas. The Indian Tea Board took various programs to protect the interests of the Indian Tea industry. GI registration process for establishing Darjeeling CTM (certification trade mark) was accomplished recently.

China

Tea consumption spread throughout the Chinese culture. Lu Yu, drawing from his vast memory, devised methods for cultivation and preparation of tea in ancient China. The perfect nature of his writings, depict Zen Buddhist philosophy learnt as a child. Missionaries introduced Zen Buddhist philosophy based tea service into imperial Japan by those missionaries. Oolong tea, popular in China, is partly oxidized and is an intermediate between black and green tea in color and taste.

Japan

Buddhist priest *viz*., Yeisei, brought the first tea seeds to Japan, as a result, he is known as the "Father of Tea" in Japan and Zen Buddhism is associated with tea in Japan. Tea got elevated to an art form creating the ‘Japanese Tea Ceremony’ ("Cha-no-yu" meaning "the hot water for tea"). To graduate in art of the Tea ceremony long years of training and practice is necessary. The total art involves the making and serving of a cup of tea. "Tea Tournaments" were conducted among the rich people and aristocrats competed to name various tea blends. Three great Zen priests (VIZ., Ikkyu, Shuko and Rikkyu) restored tea to its original place in Japanese society. Sen-no Rikkyu (1521-1591), a priest, set the rigid standards for the ceremony, which are intact even today and he was successful in influencing the Shogun Toyotomi Hideyoshi, who became Japan's greatest patron of the art of tea. He facilitated the final and complete integration of tea into Japanese life.

Europe

In 1560 Portuguese Jesuit Father Jasper de Cruz was the first European to personally encounter tea and depicted about it. Portugal had first trade with China. The Portuguese

found a route and sent their tea to Lisbon. Dutch ships brought tea to other nations like France, Holland, and the Baltic countries. It was available in common food shops throughout Holland to the public along with ginger and sugar by 1675. The public largely continued to enjoy their new beverage. Craze for things of orient swept through Europe; France and Holland spread the use of tea, making it a part of lifestyle. In 1680, the social critic Marie de Rabutin-Chantal, the Marquise de seven makes the first mention of adding milk to tea. Tavern owners supplied portable tea set complete with a heating unit to the guests, which encouraged the Dutchman to prepare tea outside the tavern's garden for himself and his acquaintances.

England

The first samples of tea reached England between 1652 and 1654. Tea promptly got popularity replacing Ale as the national drink of England. Charles II and his Portuguese bride were tea drinkers. When the monarchy was re-established, the two rulers brought this foreign tea tradition to England with them. Tea passion swept across England. Initially, the English had two main meals-breakfast and dinner. Breakfast was Ale, bread, and beef. Dinner was a long, massive meal at the end of the day. To avoid 'sinking feeling' in the late afternoon, Anna, the Duchess of Bedford (1788-1861) invited friends to join her for an additional afternoon meal. The menu centered on small cakes, bread and butter sandwiches and sweets along with tea. The first pot of tea was made in the kitchen and warmed over a small flame by hostess in a second pot (usually silver) before serving. Food and tea was then passed among the guests, the main purpose of the visiting being conversation. Later, two distinct forms of tea services evolved: High and Low. 'Low Tea' (served in the low part of the afternoon) was served in aristocratic homes of the wealthy and featured gourmet titbits. The emphasis was on presentation and conversation. 'High Tea' or 'Meat Tea' was the main or 'High' meal of the day.

Tea was also one of the major beverages served in the coffee houses. These were also called 'Penny Universities' because for a penny any man could obtain a pot of tea, a copy of the newspaper, and engage in conversation. Tea Gardens were developed in England also, after observing the Dutch *Tavern garden teas.* Lord Nelson met the great love of his life, Emma, later Lady Hamilton at such a Tea Garden. British public mixed here freely for the first time at these gardens, cutting across lines of class and birth. Women were also permitted to enter public gathering for the first time without social criticism. Tipping initiated in the Tea Gardens of England as a response to proper service. Locked wooden boxes were placed on the tables. Inscribed on each were the letters T.I.P.S., which stood for the sentence 'To Insure Prompt Service'.

Russia

The Russian interest in tea began when the Chinese embassy in Moscow presented several chests of tea to Czar Alexis during 1618. The Trade Treaty of Newchinsk established a common border between Russia and China, allowing caravans (group of camels) to cross back and forth freely. High initial cost of tea made it affordable only to affluent. The price had dropped some extent and tea was spread throughout Russian society by the end of following century. During 1900 on completion of the Trans-

Siberian Railroad the overland caravans were discarded. Tea was suited to Russian life as it was hearty, warm, and satisfying. The Samovar (viz., hot water heater and teapot), adopted from the Tibetan hot pot, placed in the centre of the Russian home and it could serve up to forty cups of tea at a time. The Russian favored strong tea highly sweetened with sugar, honey, or jam. Guests sipped their tea from glasses in silver holders, very similar to Turkish cups showing the Asian influence in the Russian culture. Tea remained a staple drink, although the revolution intervened in the Russian society. Finally, tea (along with vodka) became the national drink of Russia.

America

Peter Stuyvesant brought the first tea to America to the colonists in the Dutch settlement of New Amsterdam (now New York) during 1650. English colonists in Boston became aware of tea during 1670 and it was available for sale twenty years later. Tea Gardens were first opened in New York City. The new Gardens were centered on the natural springs. The most famous of these, Tea springs were at Roosevelt and Park Row Street. The Colony and the Mother country acknowledged tea as staple of the business among them during 1720.

American Revolution - Charles Townshend presented the first tax measures, and imposed a higher tax on newspapers, tavern, legal documents, marriage licenses, docking papers and Tea, after the war. The tax imposition without their approval caused protests of colonists and they rebelled openly by purchasing imported tea. The Tea Tax became the turning point of America's desire for freedom during 1767.

The Boston Tea Party - Events worsened enough that the men of Boston, dressed as Indians threw hundreds of pounds of tea into the harbor causing closure of the Boston port and the royal troops engaged the city. The colonial leaders declared revolution and America initiated trade with China in 1789, after the revolution. America's newer, faster clipper ships out sailed the English tea wagons. The new American ships established records for speed and distance. The Chinese trusted Thomas Perkins (member of one of Boston's oldest sailing families) as a gentleman of his word enabled him to conduct enormous transactions half way around the world without a single written contract. America was able to break the English tea monopoly because their ships were faster. Green tea, a staple in the Orient, is gaining popularity in the U.S. due to scientific studies linking green tea drinking with reduced cancer risk.

Global Tea Plantations

With support from the Crown, Scottish botanist Robert Fortune attempted various experiments in growing tea in India. Finally, after years of trial and error, the English tea plantations in India and other parts of Asia prospered. The great English tea marketing companies were established and production mechanized during the industrialization of the world.

Value added products and trendy teas

During the 20th century, two major American contributions to the tea industry occurred. In 1904, iced tea was created at the World's Fair in St. Louis. Richard Blechynden, a tea

plantation owner, planned to distribute free samples of hot tea to visitors during America's first World's Fair. No one was interested due to the hit of heat wave at that time. He dumped a load of ice into the brewed tea to save his investment. He served the first **Iced tea** and became invention of the Fair. In 1908, Thomas Sullivan of New York created tea bag, wrapped samples individually and distributed to restaurants for consideration. He recognized a natural marketing opportunity when he observed the restaurants were brewing the samples in the bags to avoid the mess of tealeaves. The prototype of this most popular of all teas was developed by the Scottish Tea Master Drysdale in Edinburgh. It was marketed simply as Breakfast Tea. It is generally offered with milk or lemon. This is useful to prepare iced tea also.

The Irish have always been great tea drinkers, and they drink their tea brewed very strong, is usually drunk only in the morning and called as Irish Breakfast. Usually it is blended from an Assam tea base. It is served with lots of sugar and milk. Caravan-this tea was created in Russia from the teas brought overland by camel from Asia and was usually a combination of black teas from China and India. Chinese Mandarin gave the blend to Earl Grey (1764-1845), prime minister of England under William IV, seeking to influence trade relations. A smoky tea with a hint of sweetness to it, it is served plain and is the second most popular tea in the world today. In general it is a blend of black teas along with essential oil of bergamot. Darjeeling tea- refers to tea grown in the eastern Himalayan mountain area of India. The mountain altitude and gentle misting rains of the region produce a unique full bodied but light flavor with a subtly lingering aroma reminiscent of Muscatel and highest grade. Reserved for afternoon use, it is traditionally offered to guests with lemon and without milk.

Oolong tea - Originally developed in the Fukien province of China. The high quality Oolong teas (Formosa Oolongs) are grown in Taiwan. This is an intermediate between green and black teas, it is fermented to achieve a delicious fruity taste. It is perfect for afternoon use with sandwiches and madelaines. Green Teas - Green tea makes up only ten percent of the world's produced tea. The Japanese green tea service is an art. Green tea is not generally part of the afternoon tea tradition. Keemun China Teas – It is the most famous of China's black teas. It is a mellow tea that will stand alone as well as support sugar and /or milk, because of its wine-like quality. It is considered the burgundy of teas due to its subtle and complex nature.

1.2. World Scenario of Production and Trade

China (32%) and India (22%) are the two largest producers of tea and both are the largest consumers as well (Figure1). The contribution of both in global tea business is 18 and 11% respectively. Other countries like Kenya, Sri Lanka, Vietnam and Indonesia contributes ~25% of World tea but control ~50% of world trade.

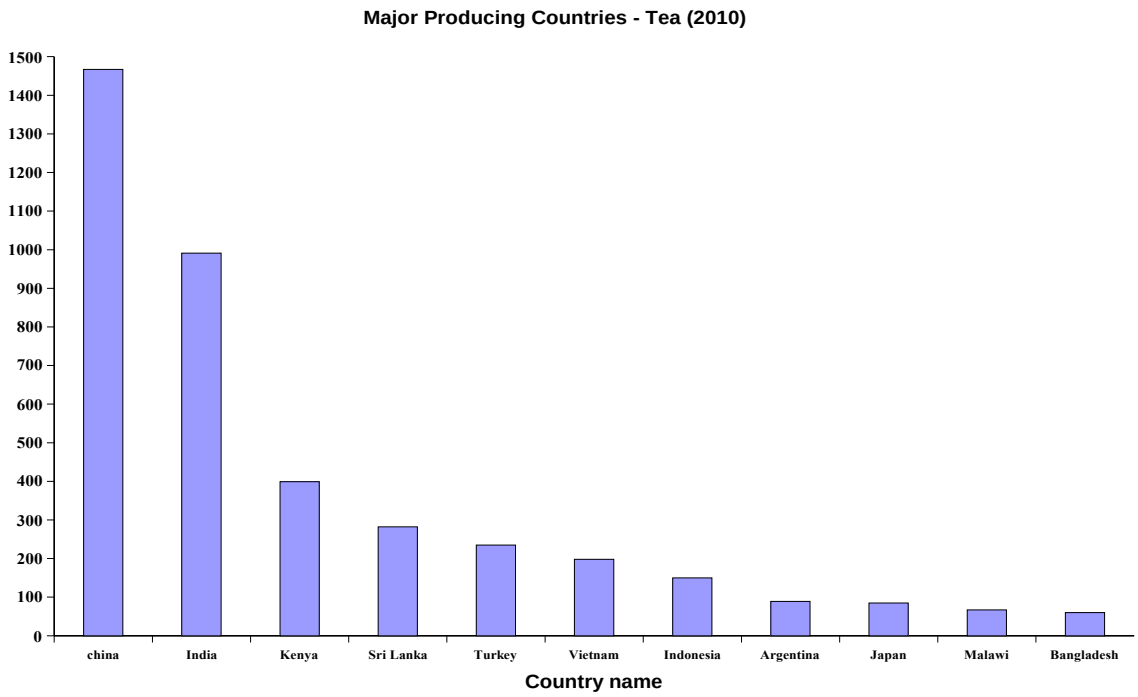

Figure 1. Major Tea Producing Countries (2010)

1.3. Botanical and Taxonomical characteristics

Tea belongs to the genus *Camellia* in the family *Theaceae.* The genus Camellia includes 82 species. Tea is commonly accepted as *Camellia sinensis* (L) O. Kuntze, irrespective of variation in characteristics. This is normally a diploid (2n=30 chromosomes) but polyploids occur. Systematic taxonomical position of tea is shown below:

Division	**Angiospermae**
Class	Dicotyledones
Order	Parietales
Family	Theaceae
Genus	Camellia
Species	sinensis

Taxonomically, four basic varieties of the tea plant are recognized commercially - China type (*Camellia sinensis* var. *sinensis*), Assam type (*Camellia sinensis* var. *assamica*), Cambodia type (*Camellia sinensis* var. *lasiocalyx*), and the hybrid of China and Assam types. Based on leaf pose and growth habitat two intra specific forms of *C. sinensis* (L.), *i.e.* China variety, *Camellia sinensis* var. *sinensis* (L.) - Growth habitat :Dwarf, slow growing, shrub like; Leaf features: Small, erect narrow, dark green; Leaf pose: Erectophile <50 degree angle. Assam variety, *Camellia sinensis* var. *assamica* (Kitamura) - Growth habitat: Tall, quick growing tree; Leaf features: Large, horizontal, broad, mostly non-serrated, light green; Leaf pose: Planophile > 70 degree angle.

1.4. General Characteristics

Tea plant is an evergreen perennial shrub most often reaching a height of 20-30 ft. The leaves are of length 5.5-6.1 cm and width 2.2-2.4 cm, evergreen, elliptical, alternate, acuminate, serrated margins, glabrous sheet with pubescent on below surface, become dark green and leathery on maturity. The flower buds originate either singly or in clusters from the side buds, flowers are white with 5 to 7 leathery sepals and petals. Fruits are glabrous, brownish green in color, tetralobate with 1-3 seeds.

Tea varieties

The traditional teas are – Black tea, Green Tea, Yellow Tea, Red Tea, Dark Tea and White Tea. Among the above, three types of teas viz., Green, Black and Oolong are produced and consumed abundantly in different regions of the world. All the three types are different because these are processed to obtain various degrees of fermentation (aeration) in the final product.

Green Tea (no fermentation / aeration)

The leaves are withered in hot air and then steamed at 100±5^{o}C for 40±10sec to inactivate the enzymes (e.g., polyphenol oxidase, peroxidase, catalase etc) and thus prevent the biological reactions between the enzymes and substrates. Green tea is more popular in the Eastern countries and becoming popular in other countries due to health benefits.

Oolong Tea (partial fermentation / aeration)

The tea leaves are wilted in sunlight, crushed and left to oxidize till the edges become dark in color, then they are heated and dried. Oolong tea, also popular in the Far East.

Black Tea (complete fermentation / aeration)

Leaves (two leaves and bud) undergo biochemical reactions during fermentation stage and these are dried to obtain black tea. Chemical composition of black tea is different from green tea and oolong tea. Original components of fresh tea leaf undergo oxidation, polymerization and other modifications during processing. Enzyme inactivation (fixing) is a critical step in all the tea preparations, which provides the suitable chemical composition for tea varieties.

Tea composition and also the taste and aroma vary with climate, soil, season, horticultural practices and variety. Depending on the origin or source also, different varieties of tea are produced, with minor modification in the processing parameters with related to climatic conditions. These are represented with reference to their origin or source. Viz., Assam (India), Ceylon (Sri Lanka), Darjeeling (India), Lapsang Souchong (dried over burning pine, originally from China), Keemun (China), Yunnan (China), Nilgiri (India), Vietnamese (Vietnam), Nepalese (Nepal), Rize tea (Turkey) are some of the important varieties.

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Biographhical Sketches

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