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Tea - our refreshing inspiration

International Standards - science providing quality and health

Dr Andrew Scott, Chairman ISO TC/34 SC8, Tea

The 'divine healer' Emperor Shen Nung living in BC 2736 introduced us to t'u (tea) growing on the Ichow hills and in the valleys by the streams in Szechuan saying, '*it gladdens and cheers the heart*'. The Chinese poet Chang Meng-yan (AD 557-589) also inspired us in his poem with, '*fragrant t'u superimposes the six passions*'. Our Buddist priests in Japan brought tea seeds and plants back from their studies in China (from AD 593) and Gyoki devoted his life to sharing tea plants with us in his 49 temple gardens all around the country (AD 658-749). Abbot Yeisai continued cultivating tea on the slope of Seburi mountain at Hakata (AD 1191) and spoke of tea as '*the divine remedy and a supreme gift from heaven*' which gives us life. All this leading to the Japanese proverb, '*if man has no tea in him he is incapable of understanding truth and beauty*'. This is the inspiration for our scientists pursuing research in understanding tea qualities and glimpsing some beauty along the way.

Drinking tea is shared all around the world and is traded both as a commodity and as specialist quality tea so why do we need standards? This is an outline of the history of tea and how international standards have been developed by the international tea trade working with the International Standards Organisation and independent researchers for many years for everyone to have confidence to enjoy their delightful quality cups of tea.

The tea journey ...

Tea history is veiled in myths and folk lore intertwining with romance creating a karma resonating in every sip we drink (*Ukers 1935, 2007)*. Chinese and Japanese legends describe stories along this historical tea journey. Shen Nung's *Pen Ts'ao* (medicinal book) provides the first description of tea (BC 2736) and the well-known scholar Kuo P'o (AD 35) annotated *Erh Ya,* the chinese dictionary, with the definition of tea as '*a beverage which is made from the leaves by boiling*'. Chiang Tung's '*The family history of Chiang*' describes the sale of tea (together with vinegar, noodles and cabbage) as reflecting the dignity of the government in the Northern Sung Dynasty (AD 420-479). Tea cultivation in the interior province of Szechuan gradually extended down the Yangtze valley to the seaboard provinces and then spread through the provinces during the T'ang dynasty. The first book on tea, *Ch'a Ching* written by Lu Yu, the scholar, described the cultivation and manufacture of tea grown on the hills along the Pa Shan established the foundation for tea cultivation (AD 780). This growing enjoyment of tea brought it to the interest of other countries and led to Japan embracing tea.

Fig. 1 Lu Yu tea scholar, Chinese tea museum in Hangzhou

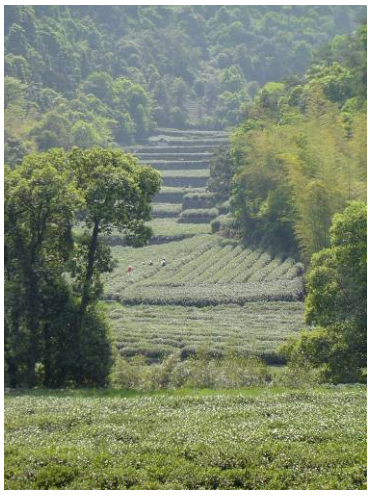

Fig. 2 Tea fields in Hangzhou, China

In Japan Prince Shotoku's leadership brought added style from the knowledge of the Chinese civilisation, fine arts, Buddhism and introduced tea. Emperor Kammu again adopted Chinese architectural styles for his imperial palace at Hei-an-kyo, the capital of peace, and enclosed a tea garden maintained by the medicinal bureau (AD 805). The Buddhist saint Saicho (Dengyo Daishi) after his studies also brought tea seeds back from China planting them in Sakamoto village at the foot of Mount Hiyei in the province of Omi (AD 805). Abbot Yeisai re-invigorated tea cultivation after a decline by planting China seeds on the slope of Seburi Mountain in the province of Chikuzen and Shokukuji at Hakata (AD 1191). His book *Kitcha-Yojoki* (the book of Tea Sanitation) describes tea as '*the divine remedy and a supreme gift from heaven*' as it became widely available to everyone. The great milestone created in 1738 by Soichiro Nagatani was the invention of the Japanese green tea manufacturing process stimulating tea drinking throughout the Japanese empire.

India initially received tea seeds from China in 1698-1702 which stimulated a new interest. This was increased when Major Robert Bruce found native tea trees growing the nearby hills of Rangpur, Sibsagar on his botanical trips when he was on a trading mission (1823). Beesa Gaum gave the seeds and plants he asked for to his brother Mr C A Bruce on his visit to Rangpur the following year. These seeds were were planted in the Commissioner of Assam's garden in Ganhati (1825) and in the Botanical Gardens in Calcutta by Dr Wallich. The expiration of the treaty with the Chinese government to supply tea prompted Lord William Bentinck, Governor General of India, to begin exploring the cultivation of tea in the Nepal hills, where it is native (1834). The cultivation of tea in Assam was established and the first shipment of tea reached England in 1838. Mr Bruce published the manufacturing method for black tea in Suddeya, upper Assam. Black tea was born.

Indonesia tea was first grown in the home garden at Tiger Canal in Batavia by Andreas Cleyer, a German naturalist and medical doctor, with some China tea seeds he brought back from Japan (1648). This lead to the exploration of growing tea plants in Java and when more tea seeds arrived from Assam in 1878 tea cultivation began in Java.

Sri Lanka cultivated coffee crops for over 100 years when it was hit by a major blight infection (*Hemileia vastrix*) in 1869 which began the transfer to tea cultivation. The Loolecondera coffee estate started tea cultivation in 1865 with seeds from the Botanical Garden in Peradeniya. Another batch of 270 Assam jat tea plants were then planted and were growing well in the Hakgala tea gardens. Initially 1080 acres were cultivated in 1875 and this increased to 305,000 acres by 1895 and the '*divine remedy*' gave new life.

Africa was introduced to tea plants when they were cultivated in the Durban Botanical gardens of the KwaZulu-Natal province, South Africa in 1850. Again flourishing coffee industry crops failed in 1877 and tea seeds from several Assam species were brought from Calcutta. Tea cultivation followed in Malawi in 1890, in Uganda in 1900, and in Kenya and Zimbabwe in 1925.

Georgia began experimental cultivation of tea plants in the Botanical Gardens at the Black Sea port of Sukhum. Agriculturalists continued growing tea by planting China tea seeds over five and a half acres in 1884 and then over 385 acres for three estates on the eastern shore of the Black Sea near Batoum. The Ministry of Agriculture established an experimental tea plant station near Chakva in 1900 and supplied seedlings to the surrounding farmers. Tea cultivation continued to expand and support the growing industry.

Tea is essentially produced from two plant varieties: the first variety of tea trees were found in south-west China speading through Sechuan, Yunnan and the Yun-Gui plateau. The second variety of native tea trees was found in Assam on the hills surrounding Rangpur, Sibsagar. These two tea plant varieties of *Camellia sinesis*, the China plant (*var. sinesis*), or jat, and the India plant

(*var. assamica*) , or jat. The China jat is a bush which grows up to 2.75 m tall with many stems and is very hardy. The Assam jat is a single stemmed tree which grows up to 18 m in height and less hardy. Modern cultivars are hybrids of these two varieties which broadens the yield and quality of the Assam jat whilst losing some of the hardiness of the China jat. These plants are the source of tea leaves from which we all now make refreshing cups of tea.

Fig. 3 *Camellia sinensis var. sinensis* (right) & *var. assamica* (left)

Tea consumption and international trade ...

The importance of tea in the global economy and intertwining in good society has come from the breadth of the growth of cultivating tea across Asia. The major tea producing and consuming countries from the beginning included China, Japan, India, Sri Lanka, Britain and Holland. These countries were, and are, all involved in the international tea trade which is now much broader throughout Asia, Europe, CSSR and the Americas. The economic history is illustrated by the earliest tax on tea being imposed in 780 AD by Emperor Tih Tsung in the Tang Dynasty and was very unpopular. Later on, the fortunes of the English East India company were involved with the tea trade from the 1700s for two centuries. The British Tea Act of 1773 enacted as law in Britain and its colonies included a tax that the USA refused to pay which resulted in the infamous ‘Boston Tea Party’ which produced a nation of coffee drinkers.

From the early beginnings in China, tea is now enjoyed by consumers all around the world. Over *5 million tonnes of tea* is now produced in over *30 countries* (*table 1, ITC Annual Statistics*) which provide over *1400 billion cups of tea* a year (*Euromonitor International, 2014*). Tea is the most consumed global beverage after water which is valued at over USD30 billion (Euromonitor International 2014) and over one and a half million tonnes of tea is consumed outside the producing countries. Drinking tea is enjoyed in over 100 countries with different styles of infusion, by young and old alike, signifying the fundamental nature of tea’s universal popularity. The billion dollar trade of tea between producing countries and consuming countries is therefore of major commercial importance and is also of key concern to many consumers. The degree of industrialization in producing countries, in the main, is much less than that in the majority of the consuming countries and tea plays an import part in their economy. Consumption varies from country to country and can vary from 0.1 to 2.0+ kg per capita per anum.

Table 1 World Production of Tea in 2016

Leading Producers	Tonnes
China	2,350,000
India	1,239,190
Sri Lanka	292,362
Japan	77,000
Indonesia	125,500
Turkey,	253,312
Vietnam	165,000
Kenya	474,808
Argentina	84,000
World Tea Production	
Asia	4,670,585
Africa	680,933
CIS	8,800
South America	93,800
Oceana	8,600
Grand Total	5,462,718

ITC Annual Bulletin of Statistics 2017

Producing tea ...

Green tea is predominantly made by hybrid plants of the China jat which is a smaller more delicate leaf than those predominantly used to produce black tea which are hybrid plants of the Assam jat. However, this is not a hard and fast rule everywhere. The manufacture of green tea starts with plucking or harvesting the leaves which are then carefully handled to keep them fresh and then processed without letting the leaf constituents combine and preventing chemical and biochemical reactions taking place (*Ukers, 1935 and Forrest, 1985*). This is achieved by treating the leaf with a heat process as soon after plucking as is practical. The chinese style of processing involves drying with pan style firing and some oven firing or steam drying. The japanese style is predominantly steam drying the leaves with some pan firing too. In both chinese and japanese styles there is a mixture of hand processing and factory processing at different levels to give different qualities of tea. This brings the moisture content of the leaves down from approximately 70% down to 3-5%.

Fig. 4 a plucked new shoot

In China there are a large variety of green teas with a range of leaf styles and grades, some tea leaves are flat, curled and some are rolled into balls like Gunpowder. In addition there are a range of teas with flowers like jasmine, some created into balls with flowers, brick teas and many others. In Japan there are a range of styles of different qualities of teas from the high quality gyokyro and tencha, the regular sencha style and the lower quality bancha style teas (*table 2*).

Table 2 Japanese styles teas

Gyokuro	A premium tea grown under shade for three weeks prior to harvesting which reduces the astringency and enhances the flavour.
Tencha	Grown under shade for three weeks prior to harvesting which reduces the astringency and enhances the flavour. Principally used to make matcha tea.
Sencha	The leaves from the first and second harvest and is the most commonly consumed tea with higher and regular grades.
Fukamushicha	These leaves are steamed for longer than regular sencha style tea with a milder taste.
Bancha	These leaves are harvested in the summer and autumn and prepared like sencha style and has a moderate astringency and flavour.
Kamairicha	These leaves are pan fired and rolled at the same time instead of steaming and lacks the characteristic fresh aroma of sencha style tea.
Hojicha	These leaves are well roasted sencha or bancha and has a savory aroma and typically a lower caffeine content.

Japanese Green Tea, 4th International Conference on O-Cha (Tea) Culture and Science.

Black tea leaves are predominantly from hybrid plants of the Assam jat. which is a larger less delicate leaf, there are small number of hybrid plants between the China jat. and Assam jat. The leaves are plucked, allowed to loose moisture to approximately 60% moisture, become flaccid and are then macerated carefully to allow the leaf constituents to mix and enable the chemical and biochemical reactions which can then create a range of liquors with a characteristic reddish-brown hue and taste (*Ukers, 1935 and Forrest, 1985*). There are two main styles of making tea: one style rolls the leaf to mix the internal constituents and this is known as the orthodox style; the second style cuts, tears and curls the leaves to mix the internal constituents and this is known as the CTC style. The oxidation of the mixed constituents of is often between 30-60 minutes and develops the different styles and qualities. Again the the leaves are then dried in an oven to bring the moisture down from approximately 50-60% to 3-5%.

Oolong tea is made in a way to be in-between green and black tea with some oxidation of the constituents which is much less than black tea leaf (*Ukers, 1935 and Forrest, 1985*).

The main constituents of tea leaves are the polyphenols which in green leaves are predominantly the smaller polyphenols called catechins (table 3 and 4). The oxidation of the catechins in the black tea manufacturing process produces larger polyphenols called theaflavins and thearubigens which produce the main differences in appearance and taste (table 3 and 4). The other key constituents of both green and black tea are caffeine and a unique amino acid called L-theanine which is only found in tea and a mushroom called *Xerocomus badius.*

Table 3 Tea green leaf composition

Component	% dry weight (g/100g)
Polyphenols	30
Methylxanthines (including caffeine)	3.5
Amino acids	4
Organic acids	1.5
Carotenoids	<0.1
Volatiles	<0.1
Carbohydrates	25
Protein	15
Lignin	6.5
Lipids	2
Chlorophyll	0.5
Ash	5

Graham, H N (1992) Prev Med 21, 526-531

Table 4 Comparison of green and black tea composition

Component	Green tea			Black tea		
	ave	min	max	ave	min	max
	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g
Moisture	5.68	1.30	9.19	6.27	1.23	9.94
Caffeine	2.6	1.44	4.9	3.17	1.16	5.01
GA	0.07	0.02	0.18	0.23	0.1	1.3
TG				0.99	0.17	1.56
TB	0.15	0.03	0.41	0.35	0.08	1.59
EGC	2.39	0.36	5.24	0.9	0.06	4.5
+C	0.23	0.01	3.83	0.31	0.02	2.17
EC	0.73	0.1	6.09	0.51	0.04	3.94
EGCG	6.72	2.99	12.69	1.88	0.02	9.38
ECG	1.73	0.26	7.19	1.09	0.1	5.21
Total catechins (TC)	11.72	6.57	21.38	3.96	0.16	14.7
Total Polyphenols (TPP)	16.35	9.95	25.79	15.2	7.96	26.26
Ratio	0.72	0.5	1.11			
Total Polyphenols - Total catechins	4.77	0.06	11.25	11.44	5.29	21.07

Obuchowicz, J et al (2011) J Food Comp and Analysis 24 (3), 411-417

Black tea can be enjoyed both with, or without, milk. It is not surprising therefore that this major international trade in tea requires some basic guidelines to ensure the producers cultivate, sell and consumers purchase tea of a quality which is expected from day to day and from year to year. Being from a plant, tea leaves have natural variations due to climatic and agronomic changes; however, in the main there are basic characteristics which can be measured to maintain the qualities which are expect.

International Standards for tea consumers and international trade ...

International standards are critical requirements for the international trade in tea, to ensure consumers' expectations are met, supporting the minimum benchmarks for the Good Manufacturing Practices of both black and green tea through minimum compositional specifications and to provide validated methods of analysis. Tea can be grown in some of the world's remote locations but this is not always the case as can be seen in China, Japan, India and across the continents of Asia, Africa and South America. There are challenges in developing standards for tea, fine tuning and validating methods of analysis and ensuring that the different tea estates cultivating and manufacturing tea can analyse teas during their local regular processing and innovation work as well as the international regulatory authorities at their sophisticated scientific laboratories. In this way tea producers can demonstrate that they produce the quality of the teas which meet the International Standards for consumers all over the world. Trade expectations clearly require that good manufacturing practices, quality conservation during economic transport and that the tea meets the requirements for high speed packing and attractive presentation for the supermarkets around the world.

The importance of the international tea trade to set standards was recognised in the late 1960s and early 1970s that the qualities should be established to smooth the progress of trade and to ensure consumers' expectations are met. The tea committee was established and became part of ISO as Working Group 8 in the early 1970's and was fully established as a subcommittee (SC 8) of the Technical Committee 34 Food in 1976. The good work of the committee started to made early progress by publishing the black tea standard (ISO 3720) in 1977; this year is the 40th anniversary of the publication of this standard. This established the basic parameters for good manufacturing practice for guidance with leaf plucking and tea sorting standards, prevent the sale of spent leaf and prevent the use of traditional adulterants. The definition of black tea was developed and provided the basic specifications of extractable solids, fibre and ash. The supporting work developing the analytical methods for preparing samples and measuring moisture content, extractable solids, fibre and ash content was validated in ring trials with laboratories representing both producing and consuming countries. This provided the 7 published ISO analytical methods which established the means of measuring the basic tea parameters. These methods form the basis of the international trade of tea and are used for auditing purposes and for resolving of trade requirements.

In parallel with this work, methods for sampling tea (ISO 1839), for the preparation of liquor for use in sensory tests (ISO 7516), and for a glossary of terms relating to black tea were established to aid a common language (ISO 6078) were also developed. Black tea is manufactured on a daily basis in season and a large volume of this production is sold at auction. This means that samples are distributed to agents and purchasers around the world to evaluate the organoleptic qualities of the tea to determine if it is suitable either for direct sale or for use in the familiar blends of tea we find on the supermarket shelves around the world. These methods are used everyday in the tea sales rooms for tea selection, valuation and

Fig. 5 ISO green tea and black tea sensory tasting

purchase. An ISO tea grading nomenclature system (ISO 11286) has also been established to define different sizes and grades of tea leaf which can be used as part of this evaluation process.

The next phase of work involved developing a standard for instant tea (ISO 6079) which is not only used for a more convenient way of preparing tea but is also a key ingredient in iced tea whether in the ready-to-drink form, and is increasingly becoming available, or in the dry mixes form which is available in countries where iced tea is very popular.

The advent of bulk packaging and containerization meant that the traditional tea chests became less economically viable, and they were also not ideal for protecting tea from moisture and taint. This identified the need for packaging for transporting tea around the world. A major work programme undertook the development of sack specification (ISO 9884-1) to provide standard dimensions for the efficient use of container space, constructed with materials with adequate strength, protection from moisture and taint together with the methods for testing. The second part of the standard (ISO 9884-2) defines the performance specification for the sack. This defines the material specifications and performance characteristics which can be used to evaluate alternatives which are found to be acceptable.

International Standards for tea composition ...

The programme then focused on the development of compositional analytical methods for tea. The first analysis method for measuring caffeine in tea and instant tea (ISO 10727) was originally published in 1995 and has been updated to improve the sensitivity for the analysis of decaffeinated tea.

Analytical methods were also required to differentiate between the compositional substances characteristic in green tea and black tea leaves. The first is to determine total polyphenol content (ISO 14502-1) and the second is to determine catechins (ISO 14502-2) which were both published in 2005. These methods are becoming even more important not only for tea quality validation but also because in recent years there has been an increasing interest in the health benefits of tea consumption. The working group including participants in the UK, Germany, China and initially Malawi which evaluated different methods of analysis for measuring total polyphenols (flavonoids) in tea selecting the method of Singleton & Rossi (1965). The challenges were greater when developing a method to measure catechins (flavanols) in green and black tea because pure, verified chemical standards for accurate quantitation of the catechins were not then commercially available. The standards were purified and validated, circulated to the participants of the international ring trial together with HPLC columns filled with chromatographic material from the same batch so that quantitation could be verified and validated. This work has enabled the calculation of relative response factors which means that any analyst can now quantify the levels of catechins in green and black tea without the need to purchase very expensive chemical standards which may vary in their purity. This valuable work means that the methods can now be used by analysts in the laboratories on the tea estates in producing countries as well as in all tea companies in consuming countries and for government regulatory authorities without placing each at a commercial disadvantage.

These methods of analysis were then used to create a database of the compositions of green and black tea with the international laboratory team which allowed us to differentiate between green and black tea. The database needed to include teas from different seasons and different years to verify that it gave a good detailed understanding of the range of compositions of teas produced in different countries and the effects of different seasonal conditions. The results have been published and and are summarised in *table 4* (Obuchowicz et al, 2011). This database enabled the development of the green tea standard (ISO 11287) and the updated black tea standard (ISO (3720) which were both published in 2011.

One of the high quality teas traded internationally is white tea and there is potentially a range of teas being traded which may not be of the correct quality so work is progressing on developing the understanding of how to differentiate white tea from green and black tea. A Technical Bulletin for White Tea (PD ISO/TR 12591) was published in 2013 to outline how the work is progressing.

The other major compositional element in tea is L-theanine, a unique amino acid which is associated with the umami taste in tea. This was a complicated method of analysis which was only available in a few specialist laboratories. Purified L-theanine has been used with approximately 20 tea laboratories around the world and a method of analysis has been developed and validated. This method is being prepared for publication as an ISO standard in 2017 and can be used by laboratories all internationally, even on tea estates. The key requirement is that the tea sample must be validated as from pure tea leaf and not contaminated.

The scientific diligence of the committee has ensured that all the methods of analysis have been carried out by approximately 20 laboratories around the world. The results have been analysed for replication and reproducibility within and between each laboratory and validated statistically. The data from any laboratory with results which is an outlier has been removed from the data in developing the analysis method.

ISO tea standards programme ...

The 25th ISO/TC 34/SC 8, Food Products - Tea committee meeting was held in Shizuoka in June 2015. This coincided with recognition that the Japan International Standards Committee had just upgraded its membership to a full participating member. We are honored and wish to congratulate our colleagues in their more active role. The progress of the work for new standards was reviewed and the future programme was agreed and update.

The key projects in the active programme includes developing analysis method standards and investigation the background for extending the ISO standards for teas. The projects for methods of analysis include: extension of the range of catechin tea components (ISO 14502-2); analysis of theaflavins; preparation for updating the sensory analysis of green tea infusions and a green tea sensory vocabulary. The projects investigating the parameters for teas includes: white tea, oolong tea and the characteristics for other special teas. A new project was agreed to begin the investigation of characteristics of matcha tea which can then be used for developing a tea standard.

The qualities identified in the the research of Japanese green leaf tea composition have developed data on the levels of chlorophyll, free amino acids, vitamin C, nitrogen leaf surface colour (Haraguchi et al 2002, Tsuji 2001, and Kohata et al 1999). Tea contains L-theanine, which brings up the umami (savory) taste in tea, and it is a unique amino-acid as one of the major tea component. The analysis method to detect L-theanine was complicated, so only a few specialists who belong to the research institutes were able to analyze. The analysis in order to develop the detecting method of L-theanine has been done by the 20 research institutes in the world, then validated. This method has been issued recently, and is currently available in all the world research institute including laboratories in the tea estate (ISO19563). But it is quite important to use pure and uncontaminated tea leaf in this analysis. This is the starting point for the scope and programme to develop an international standard for matcha green tea.

Achievements of ISO/TC 34/SC 8, Food Products - Tea and the future ...

Fig. 6 Tea bushes under the shade in Waduka, Sagara County, Kyoto.

Fig. 7 Matcha

The ISO sub-committee for tea (SC 8) which is part of the ISO Technical Committee for food (TC 34) has worked diligently for over 40 years and has published 25 international standards. This has provided and continues to provide the technical expertise and support for ISO to ensure consumer expectations are satisfied, to facilitate the international trade in tea, worth over USD30 billion (*Euromonitor International 2014*), and provide the guidance and common understanding of good manufacturing practices for black and green tea.

The significant achievements include the development of an ISO standard for black tea which has it's 40th years anniversary in 2017. This is supported by the ISO standards for the preparation of black tea liquor and the vocabulary, published in 1980 and 1982, which are the methods used by all tea buyers over the world to assess tea quality and agree the value and purchase price for the tea. These standards alone have facilitated the international trade in tea for over 35 years and ensured that the consumers expectations of tea quality without any contamination are met. In addition the methods of analysis for caffeine, total polyphenols and catechins and the recently published method for L-theanine analysis are major breakthroughs for the tea estates and tea companies.

For the future, tea standards also support the understanding of the positive health benefits of consuming tea which requires consistency of the composition in green and black tea leaf and beverage composition following infusion. Progress in research for benefits in health continues to be reported at the International Scientific Symposia on Tea and Human Health supported by the Tea Association of the USA since 1991. The 5th Symposia reports were published in 2013. There are an increasing number of studies reporting support for positive benefits of green for weight management and for green and black tea for the protection against cardiovascular disease; for reducing gastrointestinal, lung, prostate, breast and skin cancer; and with facilitating the management of diabetes. There also studies reporting that the amino acid L-theanine with caffeine in tea assists in improvement of cognitive function, alertness and mood. The research data to date has supported a health claim being granted by the Canada Food Inspection Agency for the consumption of green tea which helps to protect blood lipids from oxidation.

The significance of ISO standards for ensuring the quality of tea being traded gives consumers confidence that teas have a minimum benchmark of quality. This also provides confidence that there is a positive support of the health benefits of tea which are being reported in the scientific clinical studies.

When you sip your cup or glass of tea and drifting into pleasure, you can rest assured that many experts in the trade are working with the officers at the International Standards Organisation to ensure you enjoy '*the divine remedy and a supreme gift from heaven*' and are '*capable of understanding truth and beauty*'.

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About the author

Dr. Andrew Scott, Chairman ISO/TC 34/SC - 8 Food Products - Tea Committee, Foreign Special Member of the World Green Tea Association (Japan)

Dr. Scott is a biochemist with research experience in drug metabolism (doctoral studies at the University of Surrey supported by Glaxo) and food biochemistry (at the Chorleywood and Campden Food Research Association). He joined The Tetley Group, now a subsidiary of Tata Global Beverages and was the company's Director, Science & Technology, bringing innovative new tea products to Tetley markets across the globe (1991-2010).

He joined Nestec Ltd as Global Tea Scientist and supported tea science research in Nestlé's global tea businesses (2011-2016). He has been a member of the BSI AW8 Tea Committee since 1991 and was appointed Chair of ISO/TC 34, Food products, SC 8, Tea, in 2004. The committee has been working on new standards to measure substances characteristic of tea, and more recently, published the new green tea standard, upgraded black tea standard, the white tea technical bulletin and will publish the L-theanine method of analysis this year.

He also worked with the Food and Agriculture Organization Intergovernmental Group on Tea since 2005 on pesticide regulations for tea in North America, EU, Australia and India and the global use of ISO Tea standards in the international trade of tea.