CHARACTERIZATION OF THE CHEMICAL CONSTITUENTS AND ANTIOXIDANT CAPACITY OF GREEN AND OOLONG TEAS (*Camellia sinensis*) MANUFACTURED IN THAILAND

MANUSCRIPT

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CHARACTERIZATION OF THE CHEMICAL CONSTITUENTS AND ANTIOXIDANT CAPACITY OF GREEN AND OOLONG TEAS (*Camellia sinensis*) MANUFACTURED IN THAILAND

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ABSTRACT

Tea in Thailand most manufactured in northern area, especially Chiang Rai, Chiang Mai, Nan, and Mai Hang Son province. The aim of this study was to determine and compare the chemical compositions and antioxidant capacity of 4 important Thai tea products.A total of 13 of green teas of 2 major cultivars, assamicaand cv. oolong no.12 (chin hsuan oolong) and 26 of oolong tea of 2 major varieties, cv. oolong no. 12 and cv. oolong no. 17 (chin shin oolong) were collected from 18 factories in Chiang Rai province in 2011. The total polyphenol content was determined according to International Organization for Standardization (ISO 14502-1). For antioxidant capacity, DPPH radical scavenging activitiy assay and ferric reducing antioxidant power assay were determined. The catechins content and caffeine content were determined using HPLC by ISO method (ISO-14502-2). Results showed that about 95% of the 39 tea samples manufactured in Thailand had moisture content below 7%, 5% of tea samples being above 7%. The total polyphenol content in green tea was found to vary from 11.86 to 21.19%GAE, while in oolong tea was found in a range of10.22 to 17.57%GAE. The caffeine content in green tea samples were in a range of 1.69 to 3.7 %, while in oolong tea samples were in a range of 1.61 to 3.26%. The catechin content in green tea samples were in a range of 8.31-14.08 %, while in oolong tea samples were in a range of 6.81-12.46%. The antioxidant capacity in green tea samples was 164.01 mmole TE/100 g dry basis, while in oolong tea samples was about132.73mmole TE/100 g dry basis. This study provided useful information for the tea industry in Thailand and other countries in processing and selecting a good-quality tea.

Keywords: antioxidant capacity,Camellia sinensis, green tea, oolong tea, Thailand

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SUMMARY

In Thailand, tea is cultivated in the north part of the country in the provinces of Chiang Rai and Chiang Mai. About 30% of the productions are commercialized in the domestic, whereas the remaining 70% are exported. Commercially grown teas in Thailand are the Assam tea (*Camellia sinensis*var.*assamica*) and the Chinese tea (*Camellia sinensis*var.*sinensis*). Two major Chinese teas are jing shuan oolong (cv. oolong no. 12) and chin shin oolong (cv. oolong no. 17).

The amount of tea polyphenols has been regarded as a quality indicator of tea. Information based on parameters, chemical standardization, and biological assays are complementary indicators of the quality of tea, regarding its biological activities. The growing popularity of tea in recent years on the basis of beneficial health effects requires additional data of chemical constituents and biological activities. The level of chemical constituents including, total polyphenols and catechins in commercially Thai teas so far has not been determined.

The objectives of this research were to determine the chemical compositions and antioxidant capacity of 4 important Thai tea products, compare the chemical compositions between tea groups, and explore the relationship between chemical components and antioxidant capacity. This study provided useful information for the tea industry in Thailand and other countries in processing and selecting a good-quality tea.A total of 13 of green teas of 2 major cultivars, *assamica*and cv. oolong no.12 (chin hsuan oolong) and 26 of oolong teas of 2 major varieties, cv. oolong no. 12 and cv. oolong no. 17 (chin shin oolong) were collected from 18 factories in Chiang Rai province in 2011.

The total polyphenol content (TPC) was determined by spectrophotometry (ISO 14502-1). For antioxidant capacity, DPPH radical scavenging activitiy assay and reducing power activity assay were determined. The catechins content and caffeine content were determined using HPLC by ISO method (ISO-14502-2).

Results showed that about 95% of the 39 tea samples manufactured in Thailand have moisture content below 7%, but about 5% of tea samples being above 7%. The total polyphenol content in green tea was found to vary from 11.86 to 21.19% GAE, in oolong tea was also found varies from 10.22 to 17.57% GAE. The caffeine content in green tea samples were in a range of 1.69 to 3.71%, and in oolong tea samples were in a range of 1.61 to 3.26%. The catechin content in green tea samples were in a range of 8.31 to 14.08 %, and in oolong tea samples were in a range of 6.81 to 12.46%. The antioxidant capacity in green tea samples was 164.01 mmole TE/ 100 g dry basis, and in oolong tea samples was 132.73mmole TE/ 100 g dry basis.

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In the partial fulfillment of the requirement for
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STATEMENT ABOUT MANUSCRIPT AND INFORMATION SOURCE

Hereby I state genuinely that the manuscript entitled **Characterization of the Chemical Constituents and Antioxidant Capacity of Green and Oolong Teas (*Camellia sinensis*) Manufactured in Thailand** is an authentic work of mine under supervision by academic advisors, and never be published in other university. All the information taken and quoted from published or unpublished works of other writers had been mentioned in the texts and attached in the bibliography at the end of this manuscript.

Bogor, 24 February 2012
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BIOGRAPHY OF AUTHOR

Atika Luthfiyyah. Was born at Probolinggo, 6th of April, 1990 from Mr. Abdul Rochim and Mrs. Tsuaibatul Aslamiyyah (Almh), as the oldest daughter from two sibling. She also has step-mother, Mrs. Siti Khadijah, and 3 sisters and brother. The Author finished her high school at SMA Darul Ulum 2 BPP-Teknologi, Jombang on 2007 and in the same year she was accepted in Bogor Agricultural University (IPB) and got full scholarship (4.5 years) from Ministry of Religion Affair (BUD Kemenag). Author choose Department of Food Science and Technology, Faculty of Agricultural Engineering and Technology, as her major in university. She actively participated in some organizations during her study at university, i.e.*UKM* FORCES (Forum for Scientific Studies), CSS MoRA, IKALUM, *Forum Indonesia Muda*(Youth Indonesian Forum)batch VII and became the volunteer in the Indonesia Menyala program cluster IPB.She also participated in some organizational events which were hold by HIMITEPA (Association of Food Science and Technology Students), such as became the commitee in the HACCP VII and PLASMA 2009. She has ever joined as the production staff of RUSNAS Corn Noodle program, SEAFAST Centre, for 1 year.

There are some achievements that she got during her study at Bogor Agricultural University. On 2008, author was awarded as best student among grantees of BUD Kemenag from Bogor Agricultural University.Author and her team also have ever been funded in the Student Creativity Program about research entitled "*Lactic Acid from Kubis Waste as the Preservative for Fish*"(2009) and community service project entitled "*Eco-Innovation Project : Green Campaign through Documentary Film about Eco-Enzyme Production in Induk Kemang-Bogor Traditional Market*"(2010) by Directorate of Higher Education, Indonesia.On 2009, she and her team became the finalist of Alquran Scientific Writing National Competition in the National Scientific Fair, Malang. On 2010, her team paper entitled "*Eco-Community Concept through Development of Eco-Enzyme to Process Organic Waste Completely at the Household Level*" was accepted in Student Creativity Program-Written IdeaCluster 2010 and alsopresented in the SUSTAIN International Conference, Kyoto, Japan.In the same year, her team paper entitled "*Dodol Zeya (Zea Mays - Soja Max) as Functional Emergency Food*" got the 4^{th} Place on Agroindustry and Agribussines Product Inovation Competition in Lampung Polytechnic School, and also bussines plan proposal entitled "*La-Velva Shorbee : The New Way to Eat Fruit*" became the 2^{nd} Runner Up on Youth Agrotechnopreneurship Competition. On 2011, her team paper entitled "*The Potential of Aceh Traditional Food in Aceh Develompent Post Tsunami*" was presented in ADIC (Aceh Development International Conference) 2011, Bangi, Malaysia.In the same year, her team paper paper entitled "*Determination of Antioxidant Activity of Indonesian Indigenous Plant Extract and Identification of High Antioxidant Activity from Its Bioactive Compound*" was accepted in Student Creativity Program-Scientific Writing Cluster 2011. She also was registered as the 1^{st} Winner of Word Smart Center Writing Competition and then the story was published in an Anthology Book entitled *Kisah Kasih Ibu*, by Dar!Mizan Press. She had a beautiful story in her last year at IPB by participated in student mobility program, credit transfer Malaysia-Indonesia-Thailand (MIT), to conduct final research entitled "*Characterization of the Chemical Constituents and Antioxidant Capacities of Green and Oolong Teas (Camellia sinensis) Manufactured in Thailand*" in Mae Fah Luang University, Chiang Rai, Thailand.

FOREWORD

Praise to Allah, the Most Glorius, for His Mercy to me. Peace be upon to Muhammad Rasulullah SAW who always be my inspiration in my whole life. The research entitled “Characterization of the Constituents and Antioxidant Capacity of Green and Oolong Teas (*Camellia sinensis*) Manufactured in Thailand” was conducted in Mae Fah Luang University, Chiang Rai, Thailand, from June to October 2011.

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Finally, I wish this manuscript is useful for everyone who read and interest in Food Science and Technology.

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Atika Luthfiyyah

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LIST OF ABBREVIATION

No	Abbreviation	Meaning
1	A-GT	*Assamica*-Green tea
2	O12-GT	Oolong no. 12 – Green tea
3	O12-OT	Oolong no. 12 – Oolong tea
4	O17-OT	Oolong no. 17 - Oolong tea
5	Var.	Variety
6	Cv.	Cultivar
7	MC	Moisture content
8	TPC	Total polyphenol content
9	CF	Caffeine
10	TCC	Total catechins content
11	GC	Gallocatechin
12	EGC	Epigallo catechin
13	C	Catechin
14	EC	Epicatechin
15	EGCG	Epigallocatechin gallate
16	GCG	Gallocatechin gallate
17	ECG	Epicatechin gallate
18	CG	Catechin gallate
19	DPPH	2,2-diphenyl-1- picryhydrazyl
20	FRAP	Ferric reducing antioxidant power
21	GAE	Gallic acid equivalent
22	TE	Trolox equivalent
23	AA	Ascorbic acid
24	db	Dry basis
25	w/w	Weight per weight

I. INTRODUCTION

1.1. Background

Tea is made from the young tender shoots (flushes) of *Camellia sinensis* (L.) O. Kuntze and is the most widely consumed drink after water, due to its refreshing and mildly stimulant effects. Freshly harvested tea leaves are processed differently to produce specific types of tea (green, oolong, and black tea). Green tea is heated to avoid enzymatic oxidation. Oolong tea is semi-fermented to permit a moderate level of enzymatic oxidation during processing and then dried. Black tea is the most thoroughly oxidized enzymatically. Worldwide, 78% of the tea consumed is black tea, which is also the most popular drink in Europe, North America, and North Africa (except Morocco), whereas green tea (20%) is drunk throughout Asia (20%). The remaining 2% is oolong tea production, which is mainly consumed in southeastern China and Taiwan (FAO 1998).

The predominant constituents of tea leaves, accounting for up to 35% of the dry weight, are the polyphenols, which include flavonols, flavones, and flavan-3-ols. Of these, 60–80% are the flavan-3-ols commonly known as catechins. Some studies support that among all tea types, green teas containthe highest amount of catechins (Lin *et al.* 2003). The major catechins include (−) -epicatechin (EC), (−)-epigallocatechin (EGC), (−)-epicatechin-3-gallate (ECG), and (−)-epigallocatechin-3-gallate (EGCG). These compounds are primarily responsible for many of the health protective properties associated with tea including anti-obesity (Thielecke and Boschmann 2009; Sae *et al*. 2011; Rains *et al.* 2011), cancer prevention (Ju *et al*. 2007; Yang *et al.* 2007; Lambert and Elias 2010; Yuan *et al*. 2011), and cardiovascular diseases prevention (Hodgson and Croft 2010; Deka and Vita 2011).Studies have shown that the quality of tea is influenced by many factors such as the cultivars, harvest season, age of the plant, climate, environmental conditions and processing conditions (Lin *et al*. 2003; Cooper *et al*. 2005; Owuor *et al*. 2008).

In Thailand, tea is cultivated in the north part of the country in the provinces of Chiang Rai and Chiang Mai (account for 85% of tea growing areas and 93% of tea production in Thailand). About 30% of the production is commercialized in the domestic, whereas the remaining 70% is exported. In 2010, Chinese Taipei, United States of America, Netherlands and Cambodia make up a great proportion of the Thai Tea export. The exported quantity and value was 2,380 tons and 4,851 USD thousand with the annual growth rate (2006-2010) 15% and 11% respectively (International Trade Center 2011). Commercially grown teas in Thailand are the Assam tea (*Camellia sinensis*var.*assamica*) and the Chinese tea (*Camellia sinensis*var.*sinensis*). Two major Chinese teas are jing shuan oolong (cv. oolong no. 12) and chin shin oolong (cv. oolong no. 17). Assam cultivar is normally used to produce green and black teas, whereas Chinese cultivars are used as raw materials for oolong tea. However, green tea produced from jing shuan oolong (cv. oolong no. 12) can also be found in Thailand.

The amount of tea polyphenols has been regarded as a quality indicator of tea (Obanda *et al.* 1997). Information based on chemical standardization and biological assays are complementary indicators of the quality of tea, regarding its biological activities. The growing popularity of tea in recent years on the basis of beneficial health effects requires additional data of chemical constituents and biological activities. The level of chemical constituents including, total polyphenols and catechins in commercially Thai teas has not been determined so far. This study will provide useful information for the tea industry in Thailand and other countries in processing and selecting a good-quality tea.

1.2. Objectives

The objectives of this research were :

- to determine the chemical compositions and antioxidant capacity of 4 important Thai tea products
- to compare the chemical compositions and antioxidant capacity between tea groups
- to explore the correlation between chemical components and antioxidant capacity.

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II. LITERATURE REVIEW

2.1. Tea

Tea is made by processing the leaves of the tea tree *Camellia sinensis*, which originated in the southern areas of Yunnan province in China, andis now spread throughout the world. This plant has been used as medicine for 5,000 years (Harbowy and Balentine 1997). The taxonomy of tea is shown in the Table 1 below.

Table 1. The taxonomy of tea

Common name	Tea
Kingdom	Plantae
Division	Spermatophyta
Subdivision	Angiospermae
Class	Dicolydone
Ordo	Guttiferales
Family	Theaceae
Genus	Camellia
Species	*Camellia sinensis*

Source : Fitri (2009)

Most commercial teas are derived from the young leaf buds of the tea plant, which are plucked and treated in one of several ways to convert them into the appropriate form for the tea markets. The bulk of the leaf is processed by one of three distinctly different methods, depending upon the characteristics of the end product (Lin 2009).

According to the different ways of processing, especially the extent of fermentation, tea is usually divided into three basic types: green tea (non fermented), oolong tea (semi fermented) and black tea (fully fermented) (Figure 1). Alternatively, with the combination of the ways of processing and the characteristic quality of manufactured tea, tea is classified into six types. They are green tea, yellow tea, dark tea (containing brick tea and pu-erh tea), white tea, oolong tea, black tea (Wan*et al.* 2009) and GABA tea as the new type of specialized tea with high content of γ-amino butyric acid (GABA) (Ou*et al.* 2009).

Most tea leaves are used for the manufacture of green or black teas, but a smaller, though still significant, quantity is processed to yield oolong tea (Wong *et al.* 2009). Tea is processed differently in different parts of the world to give green (20%), black (78%), oolong tea (2%) (Kuroda & Hara 1998).

In green tea manufacture, catechin oxidation by polyphenol oxidase is prevented by steaming (Japan) or by panning (China) (Graham 1999). The leaves retain their green colour and almost all of their original polyphenol content. Oolong tea is allowed to ferment to a limited extent and contains a mixture of catechins, theaflavins and thearubigins (Wheeler & Wheeler 2004). Black tea is produced from fully fermented leaves and has a characteristic colour and taste.

Figure 1 Various types of dry tea; a) green tea; b) oolong tea; c) black tea

The composition of green tea has been thoroughly studied up to the nineteen eighties and is now well known. Tea is the best dietary source of catechins. Epigallocatechin gallate (EGCG) is the major catechin in tea accounting for more than ten percent on a dry weight basis. However, catechin and epicatechin (EC) can also be found in chocolate, black grapes, red wine and apples (Rice-Evans, 1997). Flavonols are more widely distributed. Quercetin, kaempferol and rutin are the most important flavonols in tea. Tea contains phenolic acids mainly caffeic, quinic. Caffeic acid is also found in white grapes, berries, in most fruits, in some vegetables particularly in asparagus, olive and cabbage (Rice-Evans 1997). Tea is also a good source of methylxanthines primarily in the form of caffeine.

With the changing society of today's world, tea trends are constantly changing. They are also very different in different parts of the world. FAO projected that world green tea production would grow at a faster rate than black tea by 2.0% annually, to reach 1097.7 thousand tons by 2016. World black tea consumption is projected to expand to reach 2.69 million tons by 2016, an annual growth rate of 1.3%. China is the largest green tea consumer, with 484.9 thousand tons of green tea consumed in 2005, which accounts for 70.17 and 54.85% of its total green tea production and 54.86% of world green tea consumption in 2005 (691.0 thousand tons). Green tea consumption fluctuated from 2000 to 2005, in Japan, Vietnam, and Indonesia. The green tea consumption in Indonesia was 3.13 thousand tons in 2005. Black tea consumption was more than green tea consumption, 67.9 thousand tons in 2005 (Wan *et al.*2009).

Although different green teas may be produced by different processing techniques, the general green tea processing is achieved as follows, fresh tealeaves plucked and fixed to inactivate enzyme. Then the leaves will be rolled and dried (or fired). The moisture content of the final product (crude tea) should be less than 6%. Oolong tea has different technique of processing. However, every company usually has different techniques. The general oolong tea processing is achieved as follows: fresh tealeaves are withered and bruised (shaken). The leaves will be partially fermented then fixed and rolled. The final step in drying to get suitable moisture content (Wan *et al.* 2009).

In Taiwan, it is estimated that approximately 80% of tea produced is consumed as oolong tea (Lin 2009). Oolong tea is manufactured predominantly in Fujian, Guangdong and Taiwan provinces of China. Although oolong tea is getting more and more popular in the world, especially in China and Japan, there is much less investigation on the quality of different oolong tea in comparison with the vigorous studies on the quality of green tea and black teas. Oolong tea is a semi-fermented tea as partially chlorophylls (chl), catechins and other polyphenols (PPs) are preserved after processing owing to inactivation of enzyme by dry heating. The perceived quality of oolong teas is assessed according to their appearance of leaf tea and the color, taste and aroma of the brew and features of infused young shoots (Wang *et al.* 2010).

Oolong tea possesses the characteristics of both the unfermented green tea and fully fermented black tea. In its manufacture are applied the long withering processing of black tea manufacture, with shaking slightly to oxidise the PPs, followed by the heatblanching procedures of green tea manufacture to stabilise the oxidised and nonoxidised components in tea leaf. Unique processing makes oolong teas possess the characteristic of ‘green tea with red circumference’. This is because the fresh leaves are rotated after the withering process. The rotating process causes the friction between the leaves, disrupts the cellular tissue at the edge of leaves and causes a limited degree fermentation. Typical brew liquor of oolong tea is ‘golden brew liquor with green leaf’ with fragrant flowery aroma and a sweet, smooth and soothing taste (Hui *et al.* 2004).

2.2.Tea polyphenols

In the most simple chemical terms, phenolic compounds include a hydroxylated aromatic ring such as phenol, *p*-cresol, and 3-ethylphenol (Figure 2). Phenolic compounds comprise a large group of organic substances, and flavonoids are an important subgroup. Phenolic compounds, such as p-hydroxybenzoic acid, catechol, caffeic acid, gossypol, and quercein, are found in all plant tissues.Polyphenolics have traditionally been separated into “condensed” and “hydrolysable” tannins. These terms are somewhat confusing because both groups can be hydrolyzed. “Condensed” tannins are more correctly referred to as flavan-3,4-diolderived tannins or proanthocyanidins, and the “hydrolysable” tannins as gallotannins or ellagitannins (Fennema 1996).

Tea polyphenols, previously called tea tannis (Figure3), are also known as tea flavonoids. Tannins are a diverse group of molecules that range up to 3000 D and are formed from carbocyclic acids, phenolic acids, and sugars. The exact structures of the larger molecules are not known (Fennema 1996).

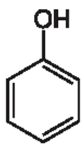


Figure 2 Phenol structure (Prahl 2012)

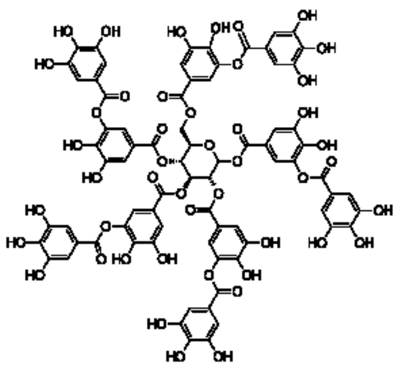


Figure 3 Plant-derived polyphenol, tannic acid, formed by esterification of ten equivalents of the phenylpropanoid-derived gallic acid to a monosaccharide (glucose) core from primary metabolism (Wikipedia 2012).

Tannin can give astringency flavour. Astringency is a taste-related phenomenon, perceived as a dry feeling in the mouth along with a coarse puckering of the oral tissue. Astringency usually involves the association of tannins or polyphenols with proteins in the saliva to form precipitates or aggregates. Additionally, sparingly soluble proteins such as those found in certain dry milk powders also combine with proteins and mucopolysaccharides of saliva and cause astringency. Astringency is often confused with bitterness because many individuals do not clearly understand its nature, and many polyphenols or tannins cause both astringent and bitter sensations (Fennema 1996).

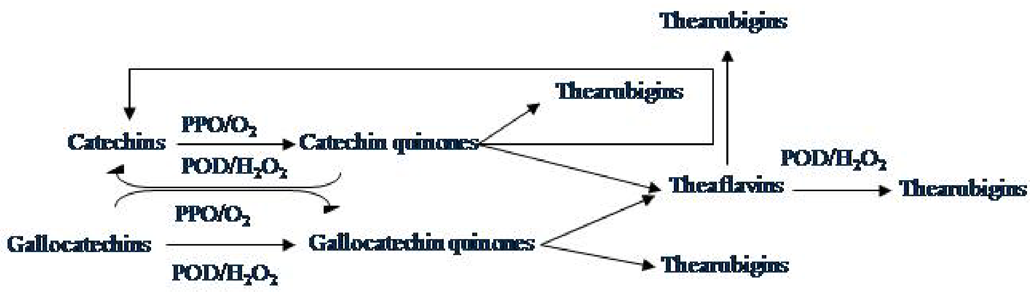
Polyphenols are important elicitors of the taste of bitterness and astringency in tea (Scharbert *et al.* 2004; Scharbert & Hofmann 2005). Among the polyphenols in fresh tea leaves, catechins are the predominant form of polyphenols, which account for 12-24% of the dry weight. Besides catechins, flavonol, and their glycosides, anthocyanidin and leucoanthocyanidin, phenolic acids and depsides are also present. These phenolic compounds are directly or indirectly associated with the characteristics of tea, including its color, taste, and aroma (Wong*et al.* 2009).

Total polyphenols in young tea shoots contains 18-36% dry basis, and their typical contents such as flavan-3-ols (catechins) 12-24%, flavonol and glycosides 3-4%, anthocyanins and leucoanthocyanidin 2-3%, phenolic acids and depsides ~5% (Wan*et al.*2003).

During fermentation process, polyphenols located within the vacuoles of the intact leaf cells are released and oxidized catalycally with polyphenol oxidases located in cytoplasm. Polyphenol oxidase can use any of the catechins as a substrate to form complex polyphenolic constituents. The catechins (Figure 4) in fresh tea leaves undergo enzymatic and chemical oxidation leading to oxidized, condensed, and polymerized polyphenols known as theaflavins and thearubigins, which contribute to the color and taste of liquors of black tea. The oxidative fermentation of catechins results in the development of appropriate flavor and color. It will cause a darkening of the leaf and a decrease in astringency. Theaflavins account for 1-3% of the dry weight of black tea. Thearubigins are by far the major components of black tea extract. They constitute as much as 10-20% of the dry weight of black tea (Wan*et al.* 2009).

Nerolidol, indole, benzenacetaldehyde, linalool, linalool oxide I, n-hexanal, benzyl nitrile, geraniol and 1-penten-3-ol were prevailing volatile compounds detected in most of oolong tea samples. These compounds together with methyl salicylate, methyl jasmonate, phenylethyl alcohol, benzyl alcohol, cis-jasmone and b-ionone are possibly principal contributor to fragrant flowery aroma of made oolong teas. Their abundant concentrations in oolong teas can be formed during tea manufacture, in which hydrolysis of their glycosides and primeverosides by b-glucosidase primeverosidase occurs intensively (Wang *et al.* 2001). Some thermal generated compounds, e.g. 3,7-dimethyl-1,5,7-octatrien-3-ol was measured in most of oolong tea samples and 2,5-dimethyl pyrazine and 5-methyl-2-furancarboxaldehyde was detected in red oolong tea. These later compounds exhibiting toasted flavour are known as heat products from AAs and sugars (Kato & Shibamoto 2001).

Enzymes have been implicated in the decolorization of tea compound. Two groups have been identified: Polyphenol oxidase (PPO) and peroxidase (POD). These enzymes are undesirable during the manufacturing of green tea (Jiang 2009).Polyphenol oxidase (1,2-benzenediol:oxygen oxidoreductase; EC 1.10.3.1) is frequently called tyrosinase, polyphenolase, phenolase, catechol oxidase, cresolase, or catecholase, depending on the substrate used in its assay or found in the greatest concentration in the plant that serves as a source of the enzyme. Polyphenol oxidase is found in plants, animals and some microorganisms, especially the fungi. It catalyzes two quite different reactions with a large number of phenols, as shown in Figure 4.



PPO: Polyphenol oxidase; POD: peroxidase

Figure 4 Scheme of the mechanism of PPO and POD to catalyze the reactions of polyphenols (Wan *et al.* 2009)

2.3.Catechins

Catechins are characterized by di- or trihidroxyl group substitution of the B ring and meta-5,7-dihidroxyl substitution of the A-ring of the flavonoid structure. Catechins posses a 1,3-dihydroxy phenyl group (A-ring) and an *o*-dihydroxy phenyl group (B-ring).Catechins are group of flavonoids belonging to flavan-3-ols. In fresh tea leaves, the principal catechins are (-)-epicatechin (EC), (-)-epigallocatechin (EGC), (-)-epicatechin gallate (ECG), (-)-epigallocatechin gallate (EGCG), catechin (C), and gallocatechin (GC). EGCG is the most abundant catechin, followed by EGC, ECG, and EC (Wan, Li, Zhang 2009). Structure can be seen in Figure 5.

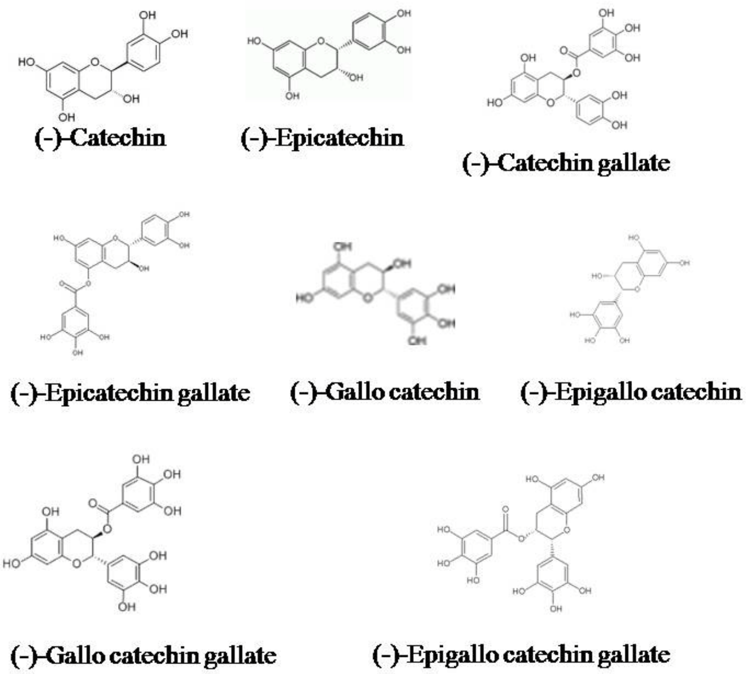


Figure 5 Various types of catechines (Wikipedia 2012)

Catechins are responsible for the astringent taste and strenght of green tea infusion. During green tea manufacture, most catechins and otherpolyphenols are preserved owing to the inactivation of the endogenous enzymes by dry heating or steaming at the initial step. green tea quality correlates positively with the concentration of polyphenols. However, a high concentration of polyphenols or catechins, which makes the infusion strongly bitter and astringent, is not necessarily required for high quality green tea. High quality green tea is characterized by high contents of free amino acids with appropriate concentrations of catechhins and caffeine (Chen *et al.* 1985).

The antioxidant activity of catechin is determined by the B-ring catechol structure and is further enhanced in gallocatechins by the 5’-hydroxyl group on the B-ring. Various structure-antioxidant activity studies have concluded that the presence of a gallate group in the 3-position and a trihydroxy B-ring plays the most important role in the free radical scavenging abilities of catechins (Salah *et al.* 1995; Nanjo *et al.* 1996).

2.4. Antioxidants

Antioxidant is a molecule capable of inhibiting the oxidation of other molecules. Oxidation is a chemical reaction that transfers electrons or hydrogen from a substance to an oxidizing agent. Oxidation reactions can produce free radicals (see Figure 6).

$$R\bullet + AH \longrightarrow RH + A\bullet$$
$$RO\bullet + AH \longrightarrow ROH + A\bullet$$
$$ROO\bullet + AH \longrightarrow ROOH + A\bullet$$

$$R\bullet + A\bullet \longrightarrow RA$$
$$RO\bullet + A\bullet \longrightarrow ROA$$
$$ROO\bullet + A\bullet \longrightarrow ROOA$$
$$\text{Antioxidant} + O_2 \longrightarrow \text{Oxidized Antioxidant}$$

Figure 6 Reaction of antioxidants with radicals (FST Ohio-state 2012)

In living organisms, reactive oxygen species are generated by many pathways and they can cause oxidative damage to important biomolecules such as lipoproteins and DNA. Antioxidants and antiradicals have received much attention because their ingestion supposedly helps to prevent in vivo oxidative damage which is associated with many diseases, including cancer, atherosclerosis, diabetes, arthritis, brain dysfunction, and immune deficiency. Consequently, there has been increasing interest in finding natural antioxidants from plants to protect the human body from the attack of free radicals and retard the progress of chronic diseases (Haslam 1996; Weisburger 1999).

The potential health benefits associated with tea consumption have been partially attributed to the antioxidant properties of tea polyphenols. Thus antioxidant activity is very important to be know in the tea. DPPH method is sensitive enough to detect active principles at low concentrations (Wan*et al.* 2009).

Although there is conflicting evidence, epidemiological studies suggest that green tea possesses diverse pharmacological properties, which include anti-oxidative (Serafini*et al.* 1996), anti-inflammatory (Mutoh *et al.* 2000), anti-mutagenic (Steele *et al.* 2000), anti-diabetic (Zeyuan*et al.* 1998), anti-bacterial (Kuroda*et al.* 2005), anti-parasitic (Molan*et al.* 2003; Molan*et al.* 2004), and anti-aging effects (Esposito *et al.* 2002). Although a number of mechanisms have been proposed for the beneficial effects of tea, the radical-scavenging and antioxidant properties of tea polyphenols are frequently cited as important contributors (Higdon & Frie 2003) to these benefical effects.

Tea polyphenols, especially catechins and theaflavins, can execute their antioxidant activities principally through scavenging free radicals, chelating transition metal ions, and modulating oxidant/antioxidant enzymes or genes. The main sites of antioxidant action of catechins are the catechol or pyrogallol group of the B-ring, the meta-5,7,-dihydroxyl group of the A-ring, and the galloyl group of the D-ring. The main antioxidant sites of theaflavins are similar to those of catechins. Antioxidant/prooxidant activity of polyphenols are dependent on many factors, such as metal-reducing potential, chelating behavior, pH, solubility characteristics, bioavailability, and stability in tissues (Wan *et al.* 2009).

2.5.Caffeine

Caffeine is the major purine alkaloid present, together with theobromine and theophylline(Wong *et al.* 2009). Structur is showed in Figure 7. Caffeine is a mild central nervous system stimulant. Although ithas been found that caffeine in tea leads to faster digit vigilancereaction time, improved rapid visual information processing accuracy,and attenuated increases in self-reported metal fatigue(Haskell*et al.* 2008), at a sufficientlyhigh dose, it may also cause flushing, chills, agitation, irritability,loss of appetite, weakness, and tremor. Hypertension,hypotension, tachycardia, vomiting, fever, delusions, hallucinations,seizures, arrhythmia, cardiac arrest, coma and death havebeen reported in cases of overdose (>200 mg/day) (Kerrigan &Lindsey 2005). Tea normally contains 20–50 mg of caffeine/g dry leaves (Yamauchi *et al.* 2008) and 24–50 mg/150 ml tea (Dixit*et al.* 2006).

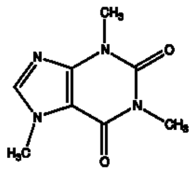


Figure 7 Caffeine structure (Wikipedia 2012)

However, it hasbeen shown that the concentration of caffeine in a cup of tea isdependent on brewing conditions, namely, water temperature,brewing duration, and leaf/water ratio (Horie, Nesumi, Ujihara, &Kohata 2002; Labbé, Tremblay, & Bazinet 2006) because brewing conditions influence the dissolution anddiffusion rates of caffeine (Spiro & Lam 1995). The form of the leaf could affect the infusion rateof caffeine in solution (Suteerapataranon 2005). It was shown that the caffeineconcentration in the tea solution prepared from rolled-leafoolong tea was less than that from loose-leaf green tea, althoughthose tea samples were produced from the same tea variety (*C. Sinensis*var.*sinensis*) grown in the same plantation.

Some other factors that could affect caffeine concentration intea infusion have been studied. The tea processing method couldhave an effect on tea quality (Muthumani & Kumar 2007a,b). Attempts had been made to study the effect of fermentation on tea quality but work on the effect of processing method on caffeine content is limited. To produce green (non-fermented), oolong (semi-fermented), and black (fermented) teas, dry leaves are steamed, rolled, and withered to different degrees. Caffeine, and also other important components, could be increased or decreased during those processes (Muthumani & Kumar 2007a,b). The caffeine concentration in fresh tea leaves is another factor affecting caffeine concentrations in tea infusions. Yang, Lambert, *et al.*. (2007), Yang, Ye, *et al.*. (2007) reported the different amounts of caffeine in *C. sinensis* (2.72%w/w) and *C. assamica*var.*kucha* (0.94%w/w) while Chen, Wang, Xia, Xu, and Pei (2005) found no significant differences among *C. sinensis*var.*sinensis*, *C. talinensis*, *C. sinensis*var. *dehungensis*, *C. crassicolumna* and *C. sinensis*var.*assamica.*

2.6.Tea Industry 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 (Commins 2008).

Tea is emerging as an economically important crop in Thailand and is earning a significant share of the beverage market.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 (Commins 2008).

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 (Commins 2008).

In 1995, 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 villages. 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 (Commins 2008).

In Thailand, tea is cultivated in the north part of the country in the provinces of Chiang Rai and Chiang Mai (account for 85% of tea growing areas and 93% of tea production in Thailand). About 30% of the production is commercialized in the domestic, whereas the remaining 70% is exported. In 2010, Chinese Taipei, United States of America, Netherlands and Cambodia make up a great proportion of the Thai Tea export. The exported quantity and value was 2,380 tons and 4,851 USD thousand with the annual growth rate (2006-2010) 15% and 11% respectively (International Trade Center 2011). Commercially grown teas in Thailand are the Assam tea (*Camellia sinensis* var. *assamica*) and the Chinese tea (*Camellia sinensis* var. *sinensis*). Two major Chinese teas are jing shuan oolong (cv. oolong no. 12) and chin shin oolong (cv. oolong no. 17). Assam cultivar is normally used to produce green and black teas, whereas Chinese cultivars are used as raw materials for oolong tea. However, green tea produced from jing shuan oolong (cv. oolong no. 12) can also be found in Thailand.

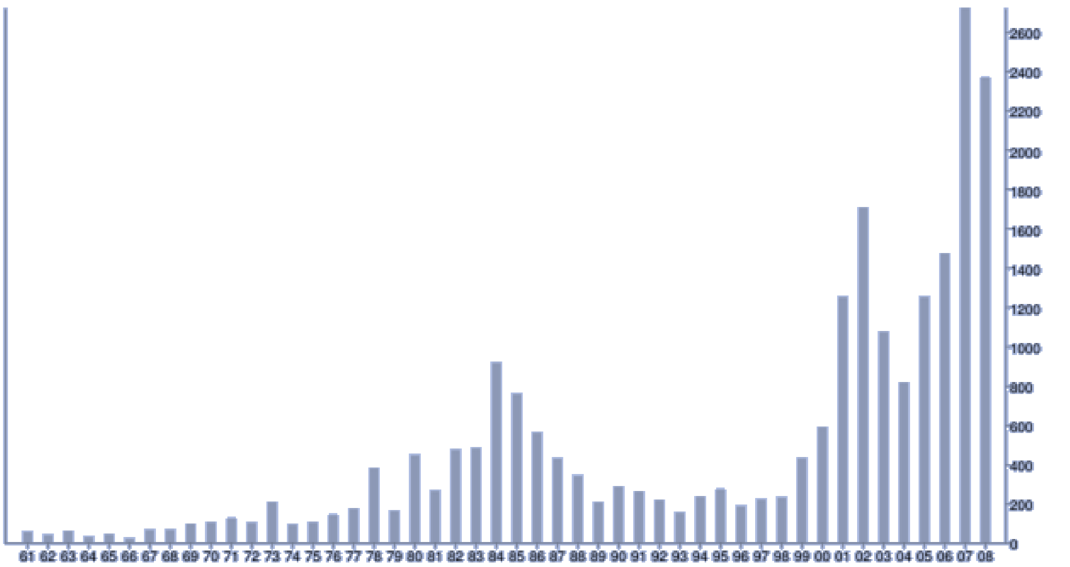


Figure 8 Graph of Export Quantity of Tea in Thailand, 1961-2008 (FAOSTAT 2008)

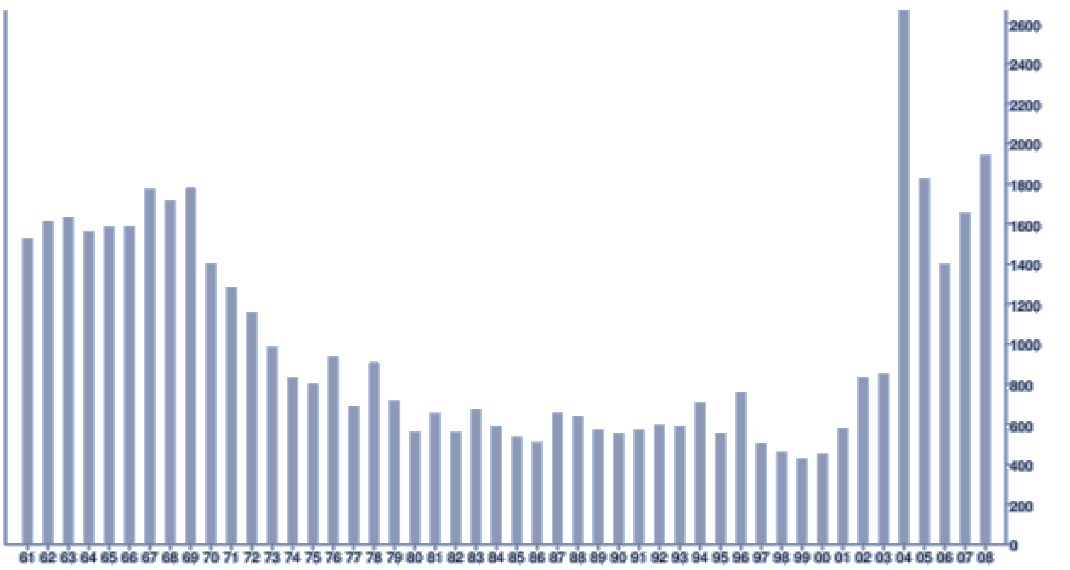


Figure 9 Graph of Import Quantity of Tea in Thailand, 1961-2008 (FAOSTAT 2008)

Table 2. Tea production rank by country in 2010

Rank	Area	Production (Int $1000)	Production (MT)
1	China	1560617	1467467
2	India	1054097	991180
3	Kenya	424327	399000
4	Sri Lanka	300219	282300
5	Turkey	249917	235000
6	Viet Nam	211064	198466
7	Iran (Islamic Republic of)	176236	165717
8	Indonesia	159521	150000
9	Argentina	94196	88574
10	Japan	90395	85000
11	Thailand	71509	67241
12	Malawi	70827	66600
13	Bangladesh	63808	60000
14	Uganda	43389	40800
15	United Republic of Tanzania	38285	36000
16	Myanmar	34456	32400
17	Rwanda	26055	24500
18	Zimbabwe	22333	21000
19	Brazil	19567	18400
20	Nepal	17661	16607

Source : FAOSTAT (2010)

III. MATERIALS AND METHODS

3.1. MATERIALS AND INSTRUMENTS

3.1. 1 Materials

3.1.1.1 Samples

A total of 13 of green teas of 2 major cultivars, *assamica* and*sinensis* / cv. oolong no. 12 (chin hsuan oolong) and 26 of oolong tea of 2 major varieties, cv. oolong no. 12 and cv. oolong no. 17 (chin shin oolong) were collected randomly from 18 factories in Chiang Rai province in 2011 (see Appendix 1). Green tea from var. *assamica* were in code A-GT and followed by number, green tea from var. *sinensis* / cv. oolong no 12 were in code O12-GT and followed by number, oolong tea from var. *sinensis* / cv. oolong no 12 were in code O12-OT, and oolong tea from var. *sinensis* / cv. oolong no 17 were in code O17-OT. Different sample code might come from same company but their brand were different.

Table 3. Sample code

Green tea var. *assamica*	Green tea var. *sinensis* / cv. oolong no. 12	oolong tea from var. *sinensis* / cv. oolong no 12	oolong tea from var. *sinensis* / cv. oolong no 17
A-GT-1	O12-GT-1	O12-OT-1	O17-OT-1
A-GT-2	O12-GT-2	O12-OT-2	O17-OT-2
A-GT-3	O12-GT-3	O12-OT-3	O17-OT-3
A-GT-4	O12-GT-4	O12-OT-4	O17-OT-4
A-GT-5	O12-GT-5	O12-OT-5	O17-OT-5
A-GT-6	O12-GT-6	O12-OT-6	O17-OT-6
	O12-GT-7	O12-OT-7	O17-OT-7
		O12-OT-8	O17-OT-8
		O12-OT-9	O17-OT-9
			O17-OT-10
			O17-OT-11
			O17-OT-12
			O17-OT-13
			O17-OT-14
			O17-OT-15
			O17-OT-16
			O17-OT-017

3.1.1.2. Chemical materials

Folin–Ciocalteu's phenol reagent and gallic acidwas purchased from Fluka (Buchs, Switzerland). Anhydrous sodium carbonate was purchased from Merck (Darmstadt, Germany). The standards which include (-)-gallocatechin (GC), (-)-epigallocatechin (EGC), (+)-Catechin (C), (-)-epicatechin (EC), (-)-epigallocatechin gallate (EGCG), caffeine (CF), (-)-gallocatechin gallate (GCG), (-)-epicatechin gallate (ECG) and (-)-catechin gallate (CG), were purchased from Sigma-Aldrich (St. Louis, Missouri, USA). Acetonitrile, trifluoroacetic acid (TFA) and methanol (HPLC-grade) were purchased from Fluka (Buchs, Switzerland). Trolox ((±)-6-Hydroxy-2,5,7,8-tetramethylchromane-2-carboxylic acid) and DPPH (2,2-diphenyl-1-

picryhydrazyl) were purchased from Aldrich (Steinheim, Germany). Methanol (HPLC-grade) was purchased from Fischer Scientific (Leicestershire, UK). Potassium hexacyanoferrate [$K_3Fe(CN)_6$] was purchased from Merck (Darmstadt, Germany). Ascorbic acid and ferric chloride ($FeCl_3$) were purchased from Ajax Finechem (Seven Hills, Australia). Monosodium phosphate monohydrate, Disodium phosphate heptahydrateand Trichloroacetic acid (TFA) were purchased from Fluka (Buchs, Switzerland).

3.1. 2 Instruments

The main instruments were a spectrophotometer (UV Vis. Biochrom/Libra S22, England), HPLC C18, oven, analytical balance,vacuum pump, blender, hot plate, water heater, setrifugator, and vortex.

3.2. METHODS

3.2.1. Sample Extraction

Collected tea samples were ground and 2 g of ground tea was extracted with 200 ml of boiling distilled water at a temperature of 95°C. The extraction mixture was constantly stirred with a magnetic stirrer. After 10 min, the extraction mixture was filtered through filter paper (Whatman No. 4). The residue was washed with distilled water (3x10ml). The tea solution was cooled to room temperature and adjusted to 250 ml with distilled water. All samples were extracted in duplicate.

Figure 10 Blender

Figure 11 Hot plate for extraction

Figure 12 Tea extract

3.2.2. Determination of Moisture Content (ISO 1573)

Tea samples, ~5 g weighed to the nearest 0.001g, were placed in a moisture can and heated in an oven at 103±2°C for at least 16 h to constant weight. The percentage of moisture in the sample were then calculated (ISO 1573). All tests were performed in duplicate.

$$\%\ \mathrm{M.C.\ (wet\ basis)} = \frac{sample\ weight\ (g) - dried\ sample\ weight(g)}{sample\ weight} x100$$

$$\%\ \mathrm{M.C.\ (dry\ basis)} = \frac{sample\ weight\ (g) - dried\ sample\ weight(g)}{dry\ weight} x100$$

Figure 13 Hot air oven (for TPC, DPPH, and FRAP assay)

Figure 14 Desicator

3.2.3 Determination of total polyphenol content (TPC) (Singleton & Rossi 1965; ISO 14502-1 2005)

The total polyphenol content (TPC) was determined by spectrophotometry, using gallic acid as standard, according to the method described by the International Organization for Standardization (ISO 14502-1). Briefly, 1.0 mL of the diluted sample extract (50-fold dilution) was transferred in duplicate to separate tubes containing 5.0 mL of 10%v/v dilution of Folin-Ciocalteu’s reagent in water. Then, 4.0 mL of a sodium carbonate solution (7.5% w/v) was added. The tubes were then allowed to stand at room temperature for 60 min before absorbance at 765 nm was measured. The concentration of polyphenols in samples was derived from a standard curve of gallic acid ranging from 10 to 100 μg/mL. The TPC was expressed as gallic acid equivalents in g/100 g dry basis (%GAE). All tests were performed in duplicate.

$$\text{Total polyphenols content (g/100g db)} = \frac{C\ x\ V\ x\ DFx\ 100}{1000{,}000\ x\ Wx\ \%DM}$$

C	= Gallic acid concentration (µg/mL) obtained from calibration curve
V	= Volume of tea extract solution (mL)
DF	= Dillution factor (25)
%DM	= % dry matter
W	= Weight of tea sample (g)

Figure 15 Spectrophotometer

3.2.4. Determination of catechins and caffeine contents (ISO-14502-2)

Preparation of samples

Theextract of teaswere diluted to 10 ml with distilled water. Then filtered through a-0.45 µm PTFE filter before HPLC analysis.

Preparation of Standards

The %purity from the certificate was used to prepare the exact concentration of stock standard solutions. The individual standard solutions of CF, GC, EGC, C, EC, EGCG, GCG, ECG, CG were prepared by dissolving them in a small volume of methanol, to generate a stock concentration of 999.0, 313.6, 412.0, 880.0, 911.8, 1,036, 1,000, 469, 832.0 and 514.8 µg/ml respectively. The mixed stock standard solution was prepared by mixing an equal volume of each stock standard. Working standard solutions were prepared by dilution of the mixed stock solution and then filtered through a-0.45 µm PTFE filter.

HPLC Analysis

HPLC analysis of standards and samples was conducted on Water 966 high performance liquid chromatography comprising vacuum degasser, quaternary pump, auto-sampler, thermostatted column compartment and photo diode array detector. The column used was a Platinum EPS C18 reversed phase, 3µm (Length 53x7mm, Internal Diameter 4.6 mm). Mobile phase eventually adopted for this study was water/acetonitrile (87:13) containing 0.05% (v/v) trifluoroacetic acid (TFA) with the flow rate of 2 ml/min. Absorption wavelength was selected at 210 nm. The column was operated at 30°C. The sample injection was 20 µl.

Caffeine and 8 catechins were identified by comparing their retention times and UV spectra in the 190-400 nm range with standards. They were quantified by external standard method and the results were expressed as g/100 g dry basis (%w/w). Total catechins content (TCC) was resolved by the addition of the amounts of individual catechins (GC, EGC, C, EC, EGCG, GCG, ECG, CG). All tests were performed in triplicates.

$$Caffeine\ or\ Catechins\ \left(\frac{g}{100\ g}\ db\right) = \frac{C\ x\ F\ x\ V\ x\ DF\ x\ 100}{10000\ x\ W\ x\ \%DM}$$

C = concentration (µg/ml) obtained from calibration curve of caffeine
F = Rf_i/RF_{cf}
V = volume of tea extract solution (ml)
DF = Dilution Factor (10)
%DM = %Dry matter
W = weight of tea sample (g)

Figure 16 Sample for injection

Figure 17 Vacuum pump for mobile phase preparation

Figure 18 Reverse phase - HPLC

3.2.5. Determination of DPPH radical scavenging activity (DPPH assay) (Yen & Duh 1994)

The extract of teas werediluted to 25 ml with distilled water. The diluted tea extract (50µl) was mixed with an aliquot of 2,000 µl of 60 µM DPPH radical in methanol. Distilled water was used as a control instead of the extract. The reaction mixture was vortex-mixed and let to stand at 25°C in the dark for 60 min. Absorbance at 517 nm was measured using methanol as a blank. The control and standard were subjected to the same procedures as the sample except that, for the control, only distilled water was added, and, for the standard, the extract was replaced with 0-1,000 µM Trolox standard. The percentage inhibition values were calculated from the absorbance of the control (A_c) and of the sample (A_s). The calibration curve was plotted between Trolox concentration (µM) and %Inhibition. The DPPH radical scavenging activity of tea sample was expressed as in terms of milimole equivalents of Trolox (TE) per 100 grams of sample (dry weight basis). All tests were performed in duplicate.

$$DPPH\ assay\ \left(\frac{mmole\ trolox}{100\ g}\ db\right) = \frac{C\ x\ V\ x\ DF\ x\ 100\ x\ 100}{1000\ x\ W\ x\ \%DM x 1000}$$

C = Trolox concentration (µM) obtained from calibration curve
V = Volume of tea extract solution (ml)
DF = Dilution Factor (25)
%DM = %Dry Matter
W = Weight of tea sample (g)

3.2.6. Determination of ferric reducing antioxidant power activity (FRAP assay) (Yen & Chen 1995)

A 1-ml aliquot of each extract (25-fold dilution) was mixed with 2.5 ml of phosphate buffer (0.2 M, pH 6.6) and 2.5 ml of a 1% aqueous potassium hexacyanoferrate [$K_3Fe(CN)_6$] solution. After a 30 min incubation at 50°C, 2.5 ml of 10% trichloroacetic acid were added, and the mixture was centrifuged for 10 min. A 2.5-ml aliquot of the upper layer was mixed with 2.5 ml of water and 0.5 ml of 0.1% aqueous $FeCl_3$, and the absorbance was recorded at 700 nm. The control and standard were subjected to the same procedures as the sample except that, for the control, only distilled waterwas added, and, for the standard, the extract was replaced with 0-1000 µM ascorbic acid standard. Iron(III) reducing activity was determined as milimole equivalents of ascorbic acid per 100 grams of sample (dry weight basis). All tests were performed in duplicate.

$$FRAP\ assay\ \left(\frac{mmole\ ascorbic\ acid}{100\ g}\ db\right) = \frac{C\ x\ V\ x\ DF\ x\ 100\ x\ 100}{1000\ x\ W\ x\ \%DMx1000}$$

C = Ascorbic acid concentration (µM) obtained from calibration curve
V = Volume of tea extract solution (ml)
DF = Dilution Factor (25)
%DM = %Dry Matter
W = Weight of tea sample (g)

Figure 19Cetrifuge

3.2.7. Statistical analysis

Samples were collected randomly. One way analysis of variance was performed with SPSS 16.0 statistical software. Differences between means were evaluated using the Duncan's multiple range test with a significance level of α = 0.05. Differences at $p \leq 0.05$ were considered significant.Correlation coefficients were calculated with Minitab 16 for antioxidant activities (DPPH and FRAP) against Total polyphenol content, caffeine, total catechins content and single catechins. Principal component analysis of 39 samples and 13 variables was performed with Minitab 16.

IV. RESULTS AND DISCUSSION

4.1. Chemical composition and antioxidant capacity of green tea and oolong tea

Chemical analyses were applied on 39 samples consist of total of 13 of green teas of 2 major cultivars, *assamica*and *sinensis* / cv. oolong no.12 (chin hsuan oolong) and 26 of oolong tea of 2 major varieties, cv. oolong no. 12 and cv. oolong no. 17 (chin shin oolong). In this research, sample was divided into four groups which were six green teas from *Camellia sinensis* var.*assamica* (A-GT), seven green teas from *Camellia sinensis* var.*sinensis* / cv.oolong no.12(O12-GT), nine oolong teas from *Camellia sinensis* var.*sinensis* / cv.oolong no.12(O12-OT), 17 oolong teas from *Camellia sinensis* var.*sinensis* / cv.oolong no.17(O17-GT).

4.1.1. Moisture content

Moisture content is an important quality parameter of teas (Roberts & Smith 1963) and is usually neglected by researchers, but not by the industries or tea traders. Tea researchers (Othieno & Owuor 1984; Robinson &Owuor 1993) suggested that the moisture content of the teas should be controlled to lie under 6.5% for marketing teas, whereas Millin (1987) noted that teas had a moisture content of 7–8% during retailing.Thai standard for tea moisture content should be controlled to lie under 7% dry basis (Tea Institute 1983). While Indonesia standard for tea moisture content should be controlled to lie under 8% dry basis (SNI 1996).

In this research, the results of moisture content determination was showed in Appendix 2. ANOVA results showed that different brands in a group of tea type have different moisture content in the significance level 5% ($p<0.05$). The moisture content of six green tea samples from var.*assamica* were found in a range of 4.70 to 9.17% w/w db. Sample A-GT-6 was found higher than Thailand tea standard. The moisture content of seven green tea samples from var.*sinensis/*cv. oolong no. 12 were found in a range of 4.29 to 6.60% w/w db. All samples are in a range of Thailand tea standard. The moisture content of nine oolong tea samples from var. *sinensis*/cv.oolong no. 12 were found in a range of 1.18 to 8.20% w/w db. All samples are in a range of Thailand tea standard, except sample O12-OT-9 contain moisture content higher than Thai tea standard. The moisture content of 17 oolong tea samples from var.*sinensis/*cv. oolong no. 17 were found in a range of 0.83 to 6.28%w/w db. All samples are in a range of Thailand tea standard.

4.1.2. Total polyphenol content

Phenolic compounds in tea have been found to be efficient free-radical scavengers, partly due to their one-electron reduction potential, i.e., the ability to act as hydrogen or electron donors (Higdon & Frei 2003). The Folin-Ciocalteu assay is one of the oldest methods developed to determine the content of total phenols (Singleton 1965). In this work, the total polyphenol content of samples were analyzed by Folin Ciocalteu method. Results are presented in Appendix 3. ANOVA results showed that different brands in a group of tea type have different total phenolic content in the significancy level 5% ($p<0.05$).

Total polyphenol content in six green tea samples from var. *assamica* were found to vary from 17.01 to 21.19% GAE. The highest polyphenol content was found in the A-GT-4 and the lowest polyphenol content was found in the A-GT-6. Duncan test divided the six samples of green tea var. *assamica* (A-GT) into 4 subsets. Samples in the same subset mean those samples were not significant different each other, such as sample A-GT-1, A-GT-3, and A-GT-5. Sample A-GT-4 (21.19% GAE) has the highest total polyphenol content among all samples and showed significant difference with other samples. Green tea samples from var. *assamica* were the highest range of total polyphenol content among all sample groups.

The different results have shown in the green tea samples from var. *sinensis* (cv. oolong no. 12). Total polyphenol content in seven green tea samples from var. *sinensis* were found to vary from 11.86 to 17.68% GAE. The highest polyphenol content was found in the sample O12-GT-3 and the lowest polyphenol content was found in the sample O12-GT-5. Duncan test divided the 7 samples of green tea var. *sinensis* (cv. oolong no. 12) into 5 subsets. Significant differences were found among the samples, such as between sample O12-GT-1, O12-GT-4, and O12-GT-6.

Total polyphenol content in nine oolong tea samples produced from *C. sinensis* (cv. oolong no. 12) were found to vary from 10.22 to 17.57% GAE. The highest polyphenol content was found in the O12-GT-8 and the lowest polyphenol content was found in the O12-GT-4. Duncan test divided the 9 samples of oolong tea var. *sinensis* (cv. oolong no. 12) into 6 subsets. Significant differences were found among the samples, but sample O12-GT-8 as the highest polyphenol content showed no significant difference with sample O12-GT-7.

Total polyphenol content in 17 oolong tea samples produced from *C. sinensis* (cv. oolong no. 17) was found to vary from 13.32 to 17.79% GAE. The highest polyphenol content was found in sample O17-OT-15 and the lowest polyphenol content was found in the O17-OT-4. Duncan test divided the 17 samples of oolong tea var. *sinensis* (cv. oolong no. 17) into 8 subsets Significant differences were found among the samples.

Comparing with other country green teas, the total polyphenol content of green teas from Thailand are lower than green teas from China, as the main tea producers of the world (Yao *et al.* 2006). Comparing with fruits, the total polyphenol content of green teas and oolong teas from Thailand are higher than mango (Ma *et al.* 2011), pomegranate (Martos *et al.* 2011) and exotic fruits (pineapple, soursop, sweetsop, jackfruit, murici, papaya, mangaba, sapodilla, ciruela, umbu and tamarind) from northeastern Brazil (Almeida *et al.* 2011), coffee (Schulz *et al.* 1999), and black tea (Khokhar and Magnusdottir 2002). Mango (*Mangifera indica* L.), as well as citrus fruits, can be considered a good source of dietary antioxidants, such as ascorbic acid, carotenoids and phenolic compounds.

Table 4 Total polyphenols content of different source

Source	Total polyphenols content	Reference
Green tea (Thailand)	11.52-20.83% GAE	
Green tea (China)	21-23% GAE	Yao *et al.*(2006)
Green tea	6.58–10.62	Khokhar and Magnusdottir (2002)
Oolong tea (Thailand)	9.86 to 16.49% GAE	
Black tea	8.05–13.49	Khokhar and Magnusdottir (2002)
Instant Coffee	14.6–15.1	Schulz et al. (1999)
Ground coffee	5.25–5.70	
Mango	0.009 to 0.193%	Ma *et al.* 2011
Pomegranate	0.01%	Martos *et al.* 2011

in g Gallic Acid Equivalent/100g dry matter

4.1.3. Antioxidant capacity

Antioxidant capacity was determined by DPPH radical scavenging activity assay and Ferric Reducing Power Activity (FRAP) assay. DPPH measures the ability of compounds to act as an hydrogen donor while FRAP measures the ability of compounds to act as an electron donor. In DPPH assay, antioxidant capacity was expressed as in terms of milimole equivalents of trolox per 100 gram of sample (dry basis). In FRAP assay, antioxidant capacity was expressed as iron (III) reducing activity which was determined as micromole equivalents of ascorbic acid per 100 grams of sample (dry basis). Results are presented in Appendix 4. ANOVA results showed that different brands in a group of tea type have different antioxidant capacity in the significance level 5% ($p<0.05$).

Antioxidant capacity in six green tea samples from var. *assamica* were found in a range of 132.32 to 247.11mmole TE/100 g db in DPPH-assay and about 1.49 to 2.52mmole AA/100 g db in FRAP-assay. The highest antioxidant capacity in DPPH-assay was found in sample A-GT-1 and the lowest concentration was found in sample A-GT-6. The highest antioxidant capacity in FRAP-assay was found in sample A-GT-4 and the lowest concentration was found in sample A-GT-2. Different brands in a group of green tea samples from var. *assamica* showed significantly different on its antioxidant capacity.

Results of antioxidant capacity in seven green tea samples from var. *sinensis* (cv. oolong no. 12) also were expressed by DPPH assay and FRAP assay. In DPPH radical scavenging activity, antioxidant capacity were found in a range of 80.08 to 241.39mmole TE/100 g db. The highest antioxidant capacity in DPPH-assay is found in sample O12-GT-7 and lowest concentration is found in sample O12-GT-5. In FRAP-assay, antioxidant capacity were found about 0.88 to 1.34 mmole AA/100 g db. The highest antioxidant capacity in FRAP-assay is found in sample O12-GT-3 and lowest concentration is found in sample O12-GT-5. Various brands of green tea from var. *sinensis* (cv. oolong no. 12) sample group contained significantly different antioxidant capacity.

In DPPH radical scavenging activity, antioxidant capacity in nine oolong tea samples from var. *sinensis* (cv. oolong no. 12) were found in a range of 98.93 to 147.62 mmole TE/100 g db. The highest antioxidant capacity in DPPH-assay is found in sample O12-OT-7 and lowest concentration is found in sample O12-OT-4. In FRAP-assay, antioxidant capacity were found about 1.31 to 2.06 mmole AA/100 g db. The highest antioxidant capacity in FRAP-assay is found in sample O12-OT-8 and lowest concentration is found in sample O12-OT-4. Different brands in a group of oolong tea samples from var. *sinensis* (cv. oolong no. 12) showed significant difference on its antioxidant capacity.

In DPPH radical scavenging activity, antioxidant capacity in 17 oolong tea samples from var. *sinensis* (cv. oolong no. 17) were found in a range of 105.35 to 16.46 mmole TE/100 g db. The highest antioxidant capacity in DPPH-assay was found in sample O17-OT-15 and lowest concentration is found in sample O17-OT-4. In FRAP-assay, antioxidant capacity were found about 1.50 to 1.90 mmole AA/100 g db. The highest antioxidant capacity in FRAP-assay was found in sample O17-OT-15 and lowest concentration is found in sample O17-OT-14. Significant differences were found among various brands of oolong tea samples from var. *sinensis* (cv. oolong no. 17).

The TEAC values (μM/g) found in the green teas (131.90 to 379.68) and oolong teas (200.90 to 298.16) from Thailand are higher than those of other plants, which are rich in antioxidants, such as strawberry (25.9), raspberry (18.5), red cabbage (13.8), broccoli (6.5) and spinach (7.6) (Proteggente *et al*. 2002). These results indicate that the green teas and oolong teas are good sources of antioxidants. Antioxidant capacity of green teas (80.08 to 247.11 mmole TE/100 g db) and oolong teas (98.93 to 164.61 mmole TE/100 g db) from Thailand are lower than grape seed extracts (1680 to 9200 mmole TE/100 g db) (Xia *et al.* 2010). Green tea and grapes are traditional, popular beverages that have diverse health benefits including antioxidant, antimicrobial, anti-inflammatory, and anticarcinogenic properties (Xia *et al.* 2010).

4.1.4. Caffein content

Caffeine concentrations in tea infusions prepared from dried leaves of six green tea samples from var.*assamica*, seven green tea samples from var.*sinensis* (cv. oolong no.12), nine oolong tea samples from var.*sinensis* (cv. oolong no.12), and 17 oolong tea samples from var.*sinensis* (cv. oolong no.17). Samples were analyzed by Reverse phase HPLC column 18 with mix standard catechins and caffeine. ANOVA results showed that different brands in a group of tea type have different amounts of caffeine in the significance level 5% ($p<0.05$).

The caffeine content ofsix brands of green tea samples from var.*assamica* were found to vary from 3.27 to 3.71% w/w, with A-GT-1 as the highest sample containing caffeine and A-GT-5 as the lowest sample. No significant differences were found among the samples.

The caffeine content of seven brands of green tea samples from var.*sinensis* (cv. oolong no.12) were found to vary from 1.69 to 3.51% w/w, with O12-GT-7 as the highest sample containing caffeine and O12-GT-4 as the lowest sample. Significant differences were found among the various brands in group of oolong tea samples from var.*sinensis* (cv. oolong no.12).

The caffeine content of nine brands of oolong tea samples from var.*sinensis* (cv. oolong no.12) were found to vary from 1.84 to 3.26% w/w, but no significant differences were found among the samples.

The caffeine content of 17 brands of oolong tea samples from var.*sinensis* (cv. oolong no.17) were found to vary from 1.61 to 3.25% w/w, with O17- OT-5 as the highest sample containing caffeine and O17-OT-4 as the lowest sample. Various brands in a group of oolong tea sample from var.*sinensis* (cv. oolong no.17) showed significant differences.

Wang *et al.* (2010) showed that caffeine content of oolong teas from Taiwan and China were in range of 1.68 to 3.80% of the dry weight, these results were similar to the caffeine content of oolong teas in Thailand (1.61 to 3.26% of the dry weight). Lin (2009) stated that caffeine accounts for 3-6% of the dry weight of brewed tea.Tea contains about one third the caffeine of coffee, the most well known source of caffeine.But Fujioka and Shibamoto (2008) found that caffeine content in regular coffees were in a range of 1.09 to 1.65%. Ashihara and Crozier (2001) stated that caffeine is found in the highest concentrations in young leaves of first-flush shoots of var. *sinensis* (2.8% of the dry weight). The beans of most cultivars of *Arabica coffee* (*C. arabica*) contain ~1.0% caffeine, whereas *Coffea canephora* cv. Robusta (1.7%) and cv. Guarini (2.4%), *Coffea dewevrei* (1.2%) and *Coffea liberica* (1.4%) contain higher concentrations. Seeds of cola (*Cola nitida*) also contain caffeine (2.2%). Caffeine has recently been detected in flowers of several citrus species, with the highest concentrations (0.2%) in pollen.

The highest amount of caffeine in samples analyzed was found in tea sample while the lowest was found in coffee sample. The current findings demonstrate that tea contains higher level of caffeine than coffee. Growing conditions, processing conditions and other variables affect caffeine content and that certain types of tea contains somewhat more caffeine than other teas, this is in agreement with the caffeine content obtained using different samples of tea. Although coffee contains less caffeine than tea (dry weight basis), some coffee solutions contain higher concentration of caffeine than tea solutions. This is normally because coffee is ground extremely fine and more ground coffee than tea is used to make the solutions. Other reasons could be because of high quality coffee beans used in terms of caffeine content or due to comparison with low quality tea (Wanyika *et al*. 2010).

4.1.5. Catechin content

The samples were analyzed by Reverse phase HPLC, column 18, and used 8 single catechins standard. Results showed in Appendix 6. ANOVA results showed that different brands in a group of tea type have different amounts of caffeine in the significance level 5% ($p<0.05$).

The total catechins content of six brands of green tea samples from var.*assamica*were found to vary from 9.02 to 14.08% w/w. The highest total catechinscontent was found in the A-GT-5 and the lowest polyphenol content was found in the A-GT-6. In green tea produced from *C. sinensis* var.*assamica* showed significant difference in some single catechins, i.e. EGC, EC, EGCG, and ECG, but small difference in GC, GCG, and ECG. Not detected was found in CG. Total catechins content was about 51.73 to 70.27% of its total polyphenol content.

The total catechins content of seven brands of green tea samples from var.*sinensis* (cv. oolong no.12) were found to vary from 8.31 to 13.19% w/w. The highest total catechins content was found in the O12-GT-3 and the lowest polyphenol content was found in the O12-GT-5. Significant differences were found among the samples. In green tea produced from *C. sinensis*(cv.oolongno.12) showed significant difference in some single catechins, i.e. GC, C, EC, EGCG, GCG, and ECG. Not detected was found in CG. Total catechins content was about 70.15 to 74.66% of its total polyphenol content.

The total catechins content of nine brands of oolong tea samples from var.*sinensis* (cv. oolong no.12) were found to vary from 8.12 to 12.46% w/w, but no significant differences were found among the samples. In oolong tea products produced from *C. sinensis*(cv.oolongno.12) showed small differences in GCG, EGCG, and EGC. No detected number were found in CG. Total catechins content was about 70.29 to 77.98% of its total polyphenol content.

Samples in group of oolong tea products produced from C. *sinensis* (cv. oolong no. 17) showed significant difference in total catechins and all single catechins, except non detected in CG. The total catechins content was found to vary from 6.81 to 12.31% w/w. The highest total catechins content was found in the O17-OT-15 and the lowest polyphenol content was found in the O17-OT-8. Total catechins content was about 49.97 to 69.25% of its total polyphenol content.

Catechins constitute 15–30% of dry weight of green tea leaves as opposed to 8–20% of oolong and 3–10% of black tea (Amidor 2009). But it was in contrast to the catechins content of green teas and oolong teas from Thailand. In Thailand, the total catechins content of green and oolong teas were lower than in sample were found by Amidor.

4.2. Comparison of tea samples

4.2.1. Comparisonbetween green tea var.*assamica* and *sinensis* (cv. oolong no.12)

Green tea products in this research were divided into 2 varieties, *assamica* variety (*Camelliasinensis* var. *assamica*) and *sinensis*/oolong/chinese variety (*Camellia sinensis* var. *sinensis*). Assam cultivar is normally used to produce green and black teas. *Sinensis*variety is known to be a stronger ecotype than var. *assamica*, being resistant to both cold and hot drought conditions. However, var. *sinensis* is considered to be inferior in both quantity and quality of yield (De Costa *et al.* 2007). Both of them were compared to determine which variety in green tea type has higher chemical compounds and antioxidant capacity than other. The results were showed in Table 2 and 3.

The total polyphenol content of green tea products produced from *C.sinensis* var.*assamica* (19.30% GAE) were higher than green tea products produced from *C. sinensis* var. *sinensis*/chinese variety (14.90% GAE), both were significant different (p<0.05) each other. Usually, teas originating from Indian or Sri Lankan varieties (*Camellia sinensis* var. *assamica*) have higher polyphenol contents (30% GAE) (Hara *et al.* 1995) than those from the Chinese variety (*Camelliasinensis* var. *sinensis*, 20% GAE) (Harbowy *et al.* 1997). Comparing with other country green teas, the total polyphenol content of green teas from Thailand (11-21% GAE) are lower than green teas from China (21-23% GAE), as the main tea producers of the world (Yao *et al.* 2006).

Green tea products produced from *C. sinensis* var. *assamica* have higher (p<0.05) ability to inhibit DPPH radical and ferric reducing capacity than green tea products produced from *C. sinensis* var. *sinensis*. The antioxidant capacity of green tea products produced from *C. sinensis* var. *assamica* by DPPH assay were in a range of 247.11 to 132.32 mmol TE / 100 g dry basis, with a mean of 183.90mmol TE / 100 g dry basis. The antioxidant capacity of green tea products produced from *C. sinensis* var. *sinensis* were in ranged from 241.39 to 80.08 mmol TE / 100 g dry basis, with a mean of 146.97mmol TE / 100 g dry basis. In FRAP assay, antioxidant capacity of *C. sinensis* var. *assamica* (2.01 mmol AA/100g) was higher than *C. sinensis* var. *sinensis* (1.12 mmol AA/100g). Significant difference was found in FRAP-assay, but no significant difference was found in DPPH-assay.

Regarding to the comparison of total catechins content and caffeine content, green tea products produced from *C. sinensis* var. *assamica* has higher total catechins content and caffeine content (12.43% and 3.44%, respectively) than total catechins contentand caffeine content (10.86% and 2.5%) of green tea products produced from *C. sinensis* var. *sinensis.* Significant differences were found in caffeine content,but no significant differences were found in total catechins content. In single cathecins, there were significant differences in EGC, C, EC, EGCG, GCG, and ECG.

Significant difference between caffeine content in tea variety was in contrast to the findings of Suteerapataranon *et al.* (2009) who reported that tea variety did not have much effect on caffeine content in Chiang Rai tea infusions. Caffeine concentrations in different tea-varieties infusions were not significantly different. In their study, tea varieties did not play a major role. Other factors such as the altitude of the site, climate, soil composition and properties, and cultivation method, which were considered to be similar for the samples studied, might have more influence in caffeine content.

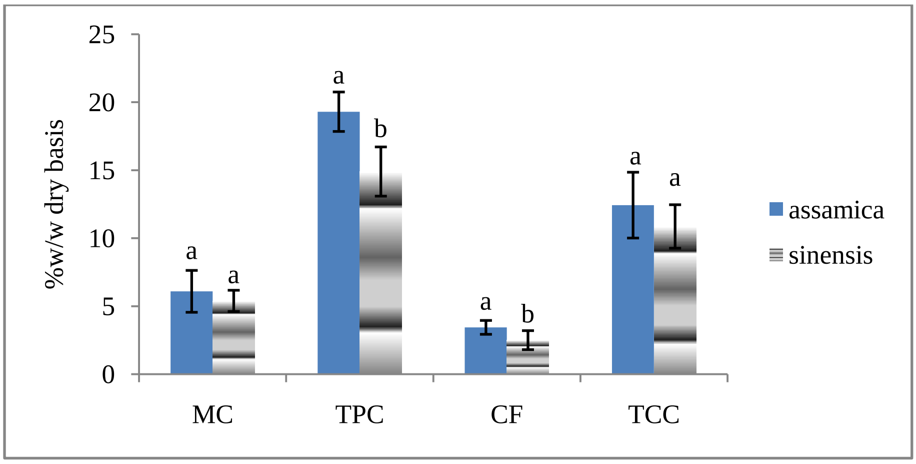


Figure 20 Comparison of mositure content, total polyphenol content, caffeine content, and total catechin content between *Camellia sinensis* var. *assamica* and var. *sinensis*

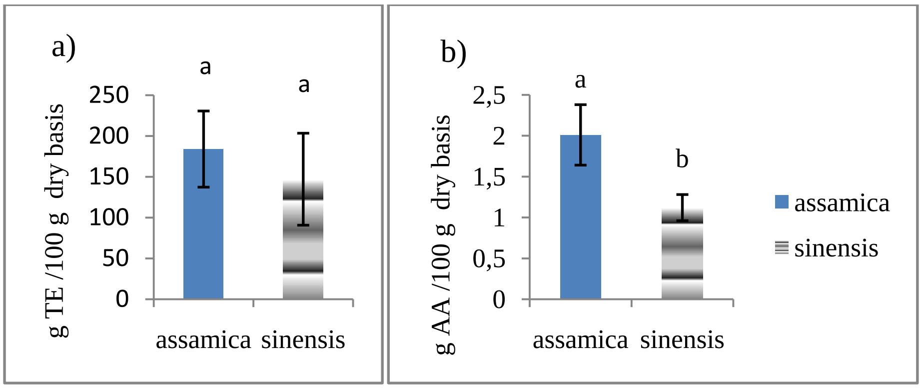


Figure 21 Comparison of antioxidant capacity by a) DPPH-assay b) FRAP-assay between Camellia sinensis var. *assamica* and var. *sinensis*

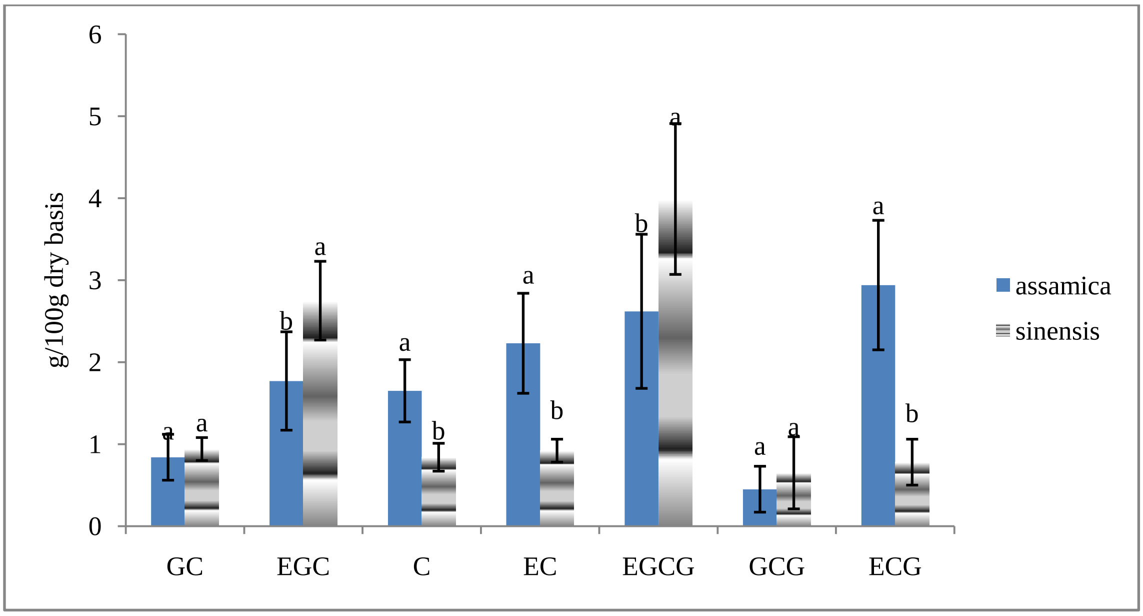


Figure 22 Comparison of single catechins content between *Camellia sinensis* var. *assamica* and var. *sinensis*

4.2.2. Comparison between *Camellia sinensis* var. *sinensis* (cv. oolong no.12) and *Camellia sinensis* var. *sinensis* (cv. oolong no.17)

Oolong tea samples in this research were come from 2 types of oolong tea, number 12 and number 17. The results of chemical composition and antioxidant capacity comparison were showed in Table 4 and 5. Significant differences only were found in moisture content, antioxidant capacity by DPPH-assay, and some single catechins (GC, ECGC, and ECG). Total polyphenol content in oolong no. 12 (14.08 g GAE/100 g dry basis) no significant difference with oolong no. 17 (14.90 g GAE/100 g dry basis). The total polyphenol content of oolong tea (10.22 to 17.79 g GAE / 100 g dry basis) manufactured in Thailand was similar to those reported for oolong tea samples from China and Taiwan (8.02 to 16.85 g GAE / 100 g dry basis) (Wang *et al*. 2010) as the most countries consuming oolong tea.

Caffeine content in oolong tea from *C.sinensis* (cv. oolong no. 12) (2.55 ± 0.61%) was no significant difference with oolong tea from *C.sinensis* (cv. oolong no. 17) (2.25 ± 0.48%). Total catechins content of oolong tea from *C.sinensis* (cv. oolong no. 12) (10.58 ± 2.17 %) also no significant difference with oolong tea from *C.sinensis* (cv. oolong no. 17) (9.94 ± 1.46 %).

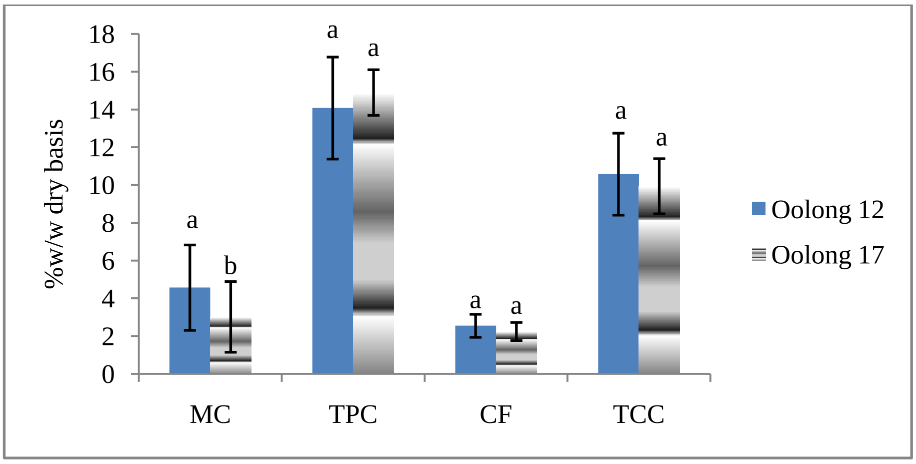


Figure 23 Comparison of mositure content, total polyphenol content, caffeine content, and total catechin content between oolong no. 12 and no. 17

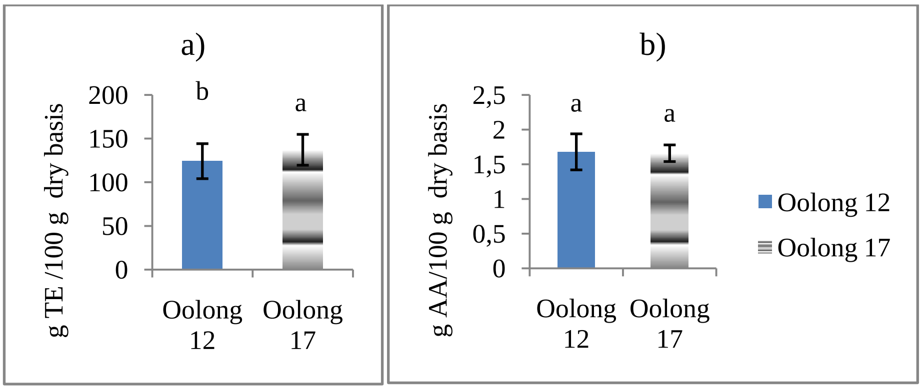


Figure 24 Comparison of antioxidant capacity by a) DPPH-assay b) FRAP-assay between oolong no. 12 and no. 17

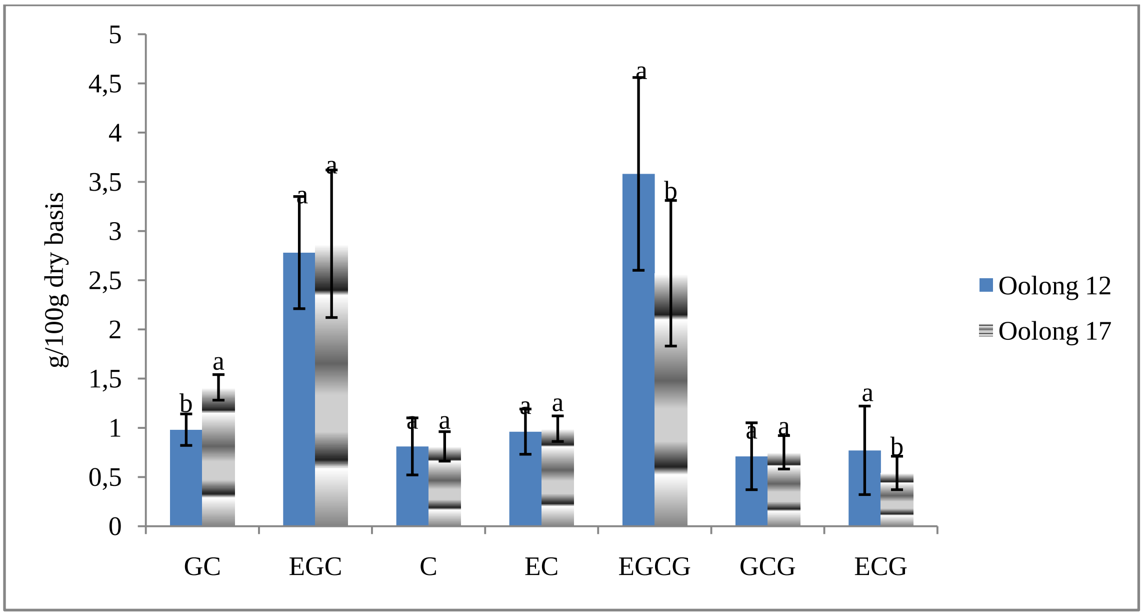


Figure 25 Comparison of single catechins content between oolong no. 12 and no. 17

4.2.3. Comparison of Green and Oolong Tea Products

Comparing between green tea group and oolong tea group, there were significant differences in moisture content, total polyphenol content, caffeine content, total catechins content, and antioxidant capacity by DPPH-assay (Table 6 and 7). The total polyphenol of green tea samples (16.93% GAE) was higher than oolong tea samples (14.62% GAE). The differences found between green tea and oolong tea could be due to fermentation process in oolong tea. It may indicate that polyphenols could have oxidized during fermentation stage of oolong tea processing. Green tea quality correlates positively with concentration of polyphenols.

Green tea has significantly higher antioxidant capacity than oolong tea by DPPH assay, but no significantly higher antioxidant capacity by FRAP method. In DPPH assay,the antioxidant capacity of green tea (164.01 mmole TE/100g db) was higher than oolong tea (132.73 mmole TE/100g db). In FRAP assay, the antioxidant capacity of green tea (1.53 mmole AA/100g db) was higher than oolong tea (1.67 mmole AA/100g db). Generally, green tea contains more of such compounds than other tea (Sikora *et al.* 2008). The green tea is preferentially recommended for its strong antioxidant properties.

Green tea has significantly higher total catechins content than oolong tea. Total catechins content in green tea was 11.63 ± 1.77 %, but 10.24 ± 1.43 % in oolong tea. In single catechin, there were significant differences in all single catechins except EGCG and no detected in CG. In this work, green tea has higher content in C, EC, EGCG, and ECG than oolong tea. But oolong tea has higher content in GC, EGC, and GCG.

The chemical composition of green tea is similar to those of fresh tea leaves (Chen *et al.* 2003). Yen and Chen (1995) found the greatest amount of catechins in green tea (26.7%), followed by oolong tea (23.2%) and black tea (4.3%). Similarly, Cabrera *et al.* (2003) found higher content of catechins in green tea than in oolong and black tea. Teas sold in Australian supermarkets, the polyphenol content of green tea (25%) was much higher than that of black tea (18%) (Yao *et al.* 2006). Lin and Shiau (2009) stated that cathecins are the main compounds in green tea; they consist of (-)-epicatechin (EC), (-)-epicatechin-3-gallate (ECG), (-)-epigallocatechin (EGC), and (-)-epigallocatechin-3-gallate (EGCG). To produce oolong, black, and pu-erh teas, the fresh tea leaves are allowed to wither, decreasing their moistire content until their weight approaches the appropriate percentage (this value is assessed by experience) of the original leaf weight. The withered leaves are then rolled and crushed, initiating the fermentation of polyphenols. This fermentation process converts catechins to theaflavins, mainly theaflavin (TF-1), theaflavin-3-gallate (TF-2a), theaflavin-3'gallate (TF-2b), and theaflavin-3,3'-digallate (TF-3), and thearubigins, consequently decreasing the catechin content.

Oolong tea has lower caffeine content than green tea (2.34 ± 0.55% and 2.93 ± 0.77%, respectively) and showed significant difference. This is in agreement to the findings of Horie *et al.* (1997) who reported that the contents of caffeine were significantly different among various kinds of teas. But, Suteerapataranon*et al.* (2010) stated that on average, the green (non-fermented) tea infusions containeda little more caffeine than did theoolong (semi-fermented) tea infusions brewed in water at 90°C and no significant difference was found between them. Thus, the different tea manufacturing methods used to produce the oolong and green tea samples used here are likely to play a major role in influencing the caffeine content in tea products.

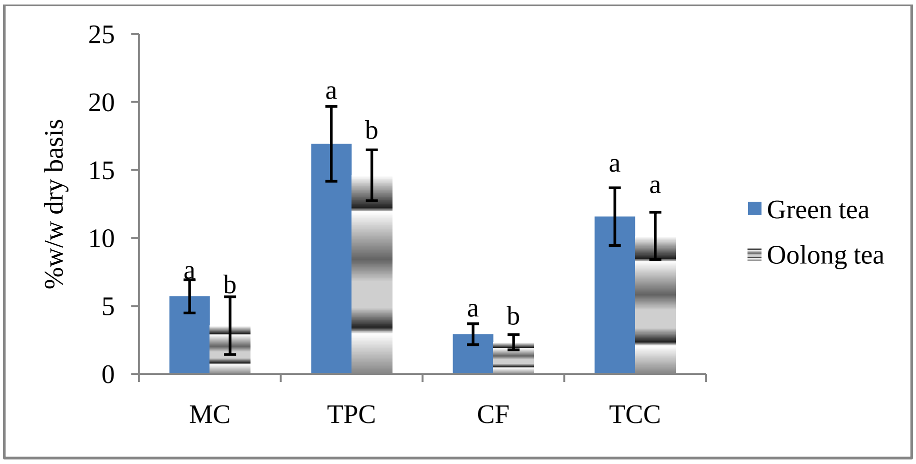


Figure 26 Comparison of mositure content, total polyphenol content, caffeine content, and total catechin content between green and oolong tea

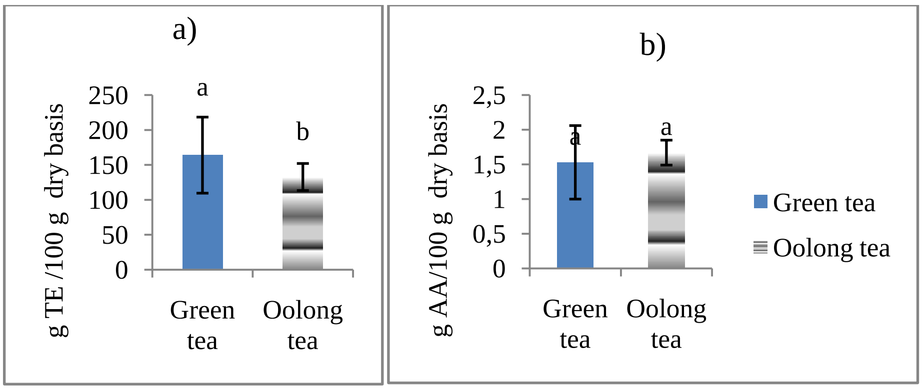


Figure 27 Comparison of antioxidant capacity by a) DPPH-assay b) FRAP-assay between green and oolong tea

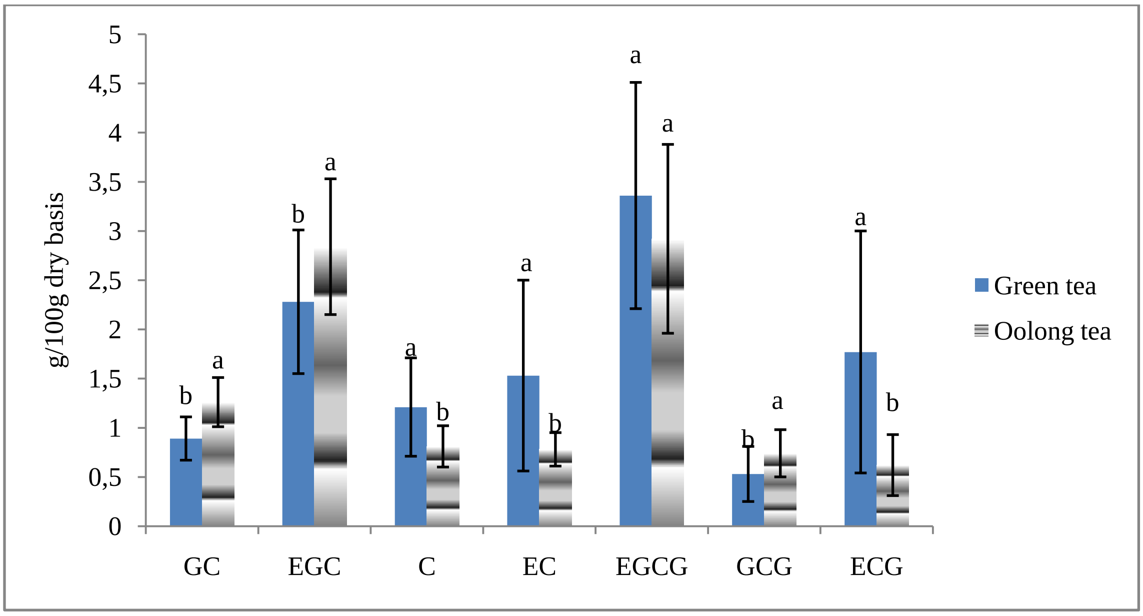


Figure 28 Comparison of single catechins content between green and oolong tea

4.3. Relationship between Chemical Composition and Antioxidant Capacity

Correlation analysis between chemical composition and antioxidant capacity, respectively (including all data for each measure) were undertaken. The total polyphenol content and the antioxidant activity are both parameters of quality for tea regarding to its biological properties (Harbowy 1997). A variable is correlated to other if the value of correlation is more than 0.5, and have high correlation if the correlation value is more than 0.8 (Limpawattana, Shewfelt 2010)

In this work as showed in Table 8, pearson's correlation analysis showed that antioxidant capacity correlated with those of total polyphenol content, caffeine content, TCC, C, EC, and ECG.The pearson's correlation between TPC and Antioxidant by DPPH and FRAP assay were the highest correlation among all, 0.649 and 0.648, respectively.

Pearson's correlation analysis also showed the direction of correlation coefficient, which were positive and negative direction, Positive direction means that the increasing of one variable ccan increase other variable, while negative direction means that the increasing of one variable can decrease the amount of other variable. In this work, positive correlation could be seen between DPPH and TPC, CF, TCC, C, EC, EGCG, and ECG, while negative correlation could be seen between DPPH and GC, EGC, and GCG. Positive correlation also could be seen between FRAP and TPC, CF, TCC, C, EC and ECG, while negative correlation could be seen between DPPH and GC, EGC, EGCG and GCG.

Pearson's correlation was also conducted to analyze the correlation in each sample groups. In sample A-GT (green tea var. *assamica*), there were no significance correlationsbetween antioxidant capacity and chemical constituents. In sample O12-GT (green tea var. *sinensis*), antioxidant capacity by DPPH-assay was strongly correlated with GC, whereas the correlation direction is negative. In FRAP-assay, there were strong correlation between antioxidant capacity and TPC, caffeine, total catechins, catechin, EC, EGCG, and ECG. All of them are in positive direction.

Table 5 Correlation coefficients of averaged chemical compound with antioxidant capacity in tea sample

Variable	All samples		A-GT		O12-GT		O12-OT		O17-OT	
	DPPH	FRAP	DPPH	FRAP	DPPH	FRAP	DPPH	FRAP	DPPH	FRAP
TPC	0.649*	0.648*	0.283	0.532	0.504	0.985*	0.972*	0.975*	0.630*	0.884*
CF	0.381*	0.209	0.585	-0.503	0.432	0.805*	-0.367	-0.371	0.298	0.609*
TCC	0.451*	0.358*	0.359	0.038	0.465	0.948*	0.755*	0.738*	-0.054	0.461
GC	-0.206	0.060	0.383	0.177	-0.824*	-0.437	0.151	0.290	0.392	0.071
EGC	-0.206	-0.119	0.224	0.264	0.124	-0.057	0.535	0.555	-0.228	0.180
C	0.467*	0.474*	-0.2	0.172	0.471	0.857*	-0.082	-0.112	0.435	0.420
EC	0.541*	0.420*	0.365	-0.495	0.679	0.899*	0.167	0.006	0.290	0.636*
EGCG	0.105	-0.083	0.136	0.443	0.511	0.964*	0.814*	0.813*	-0.127	0.348
GCG	-0.161	0.000	0.485	0.261	-0.289	0.444	0.360	0.444	0.187	0.205
ECG	0.497*	0.395*	0.071	-0.533	0.672	0.934*	0.197	0.076	0.028	0.549*

Significance : *$p<0.05$

4.4. Chemical Characteristic Profiles of Tea Samples by PCA (Principal Component Analysis)

Data results of chemical characteristics and antioxidant capacity of tea samples in different sample groups were analyzed by Principal Component Analysis (PCA) to help understanding the underlying data structure and/or form a smaller number of uncorrelated variables. Principal components analysis is commonly used in the market research, and other industries that use large data sets.

The samples were divided into 4 groups, i.e. A-GT (green tea from var. *assamica*), O12-GT (green tea from var. *sinensis*/cv. oolong no. 12), O12-OT (oolong tea from var. *sinensis*/cv. oolong no. 12), and O17-OT (oolong tea from var. *sinensis*/cv. oolong no. 17). In this work, data were analyzed by Minitab 16 statistical software. The mean of every assay would be convert to Z value, then statistical software showed eigenvalue, %variance, and cumulative%. The variable means had 13 principal components. It should be noted that the interpretation of the principal components is subjective, however, obvious patterns emerge quite often. For instance, one could think of the first principal component as representing an overall antioxidant capacity, moisture content, and chemical compositions, because the coefficients of these terms have the same sign and are not close to zero.

4.4.1. Principal Component of Green tea var. *assamica*

The first principal component has variance (eigenvalue) 5.9713 and accounts for 45.9% of the total variance. The second principal component had variance 3.7693 and accounts for 28.6% of the data variability. It was calculated from the original data using the coefficients listed under PC2. PC1 and PC2 were the principal component for further analysis. Variables in the same quadrant are close, so they vary together at least within the 74.9% of the variation that the two components explain.

For the chemical constituent and antioxidant data, DPPH, TCC, TPC, GC, EGC, GCG, EGCG and FRAP have large positive loadings on component 1. C, EC, CF, and ECG have large positive loadings on component 2. Variable DPPH, FRAP, caffeine, and catechin have short vector, it means that the data diversity is small. The data in those variables are almost similar each other. Variable TPC, GC, and EGC have positive correlation. The same case is happened between variable GCG and EGCG, also EC and C.

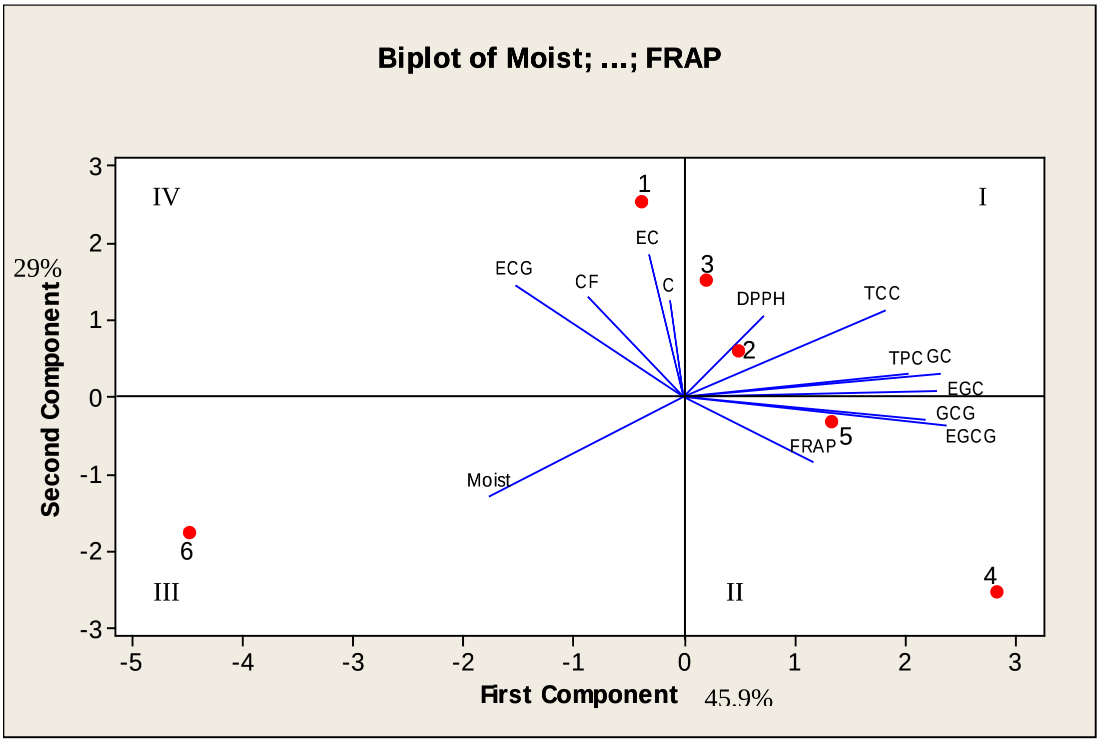


Figure 29 Biplot graph of sample green tea var. *assamica*

In a quadrant, a sample that has near distance with variable line means that sample contain high content of that variable. In quadrant I, sample A-GT-3 and A-GT-2 are close to variable DPPH, TCC, TPC, GC, and EGC. Sample A-GT-2 is close to variable DPPH and TCC. In quadrant II, sample A-GT-5 is close to variable GCG, EGCG, and FRAP. Sample A-GT-4 have highest value in variable GCG, EGCG, and FRAP. In quadrant III showed that sample A-GT-6 has highest value in moisture content. The moisture content of sample A-GT-6 is 9.2% db which is more than Thai tea standard. In quadrant IV, sample A-GT-1 has high content of C, EC, Caffeine and ECG.

4.4.2. Principal Component of Green tea var. *sinensis*

The first principal component has variance (eigenvalue) 8.2674 and accounts for 63.6% of the total variance. The second principal component has variance 2.7659 and accounts for 21.3% of the data variability. Variables in the same quadrant are close, so they vary together at least within the 84.9% of the variation that the two components explain.

For the chemical constituent and antioxidant data, caffeine, cathecin, total cathecins, EGCG, FRAP, TPC, ECG, and EC have large positive loadings on component 1. DPPH and EGC have large negative loadings on component 2. Variable EGC has short vector, it means that the data diversity is small. The EGC data values are almost similar each other. Variable FRAP and TPC are positively related to caffeine, cathecin, total cathecins, EGCG. So when one is high (relatively) for a sample, the other is high. DPPH is also positively related to EC and ECG.

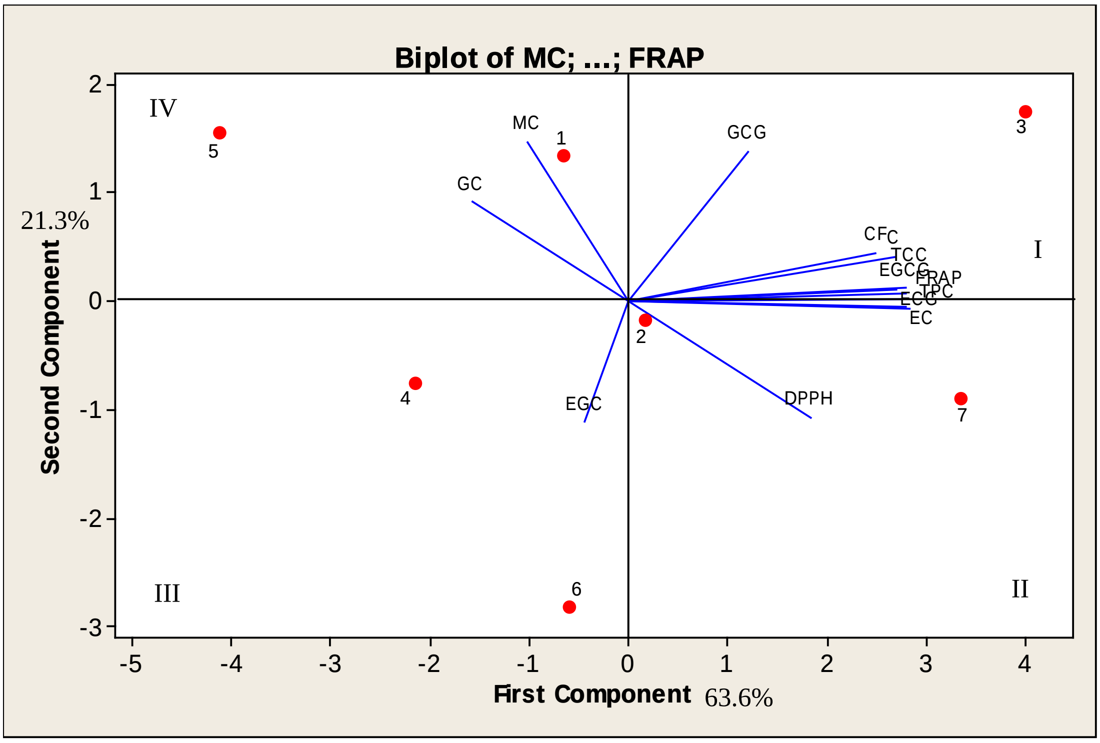


Figure 30 graph of green tea var. *sinensis* (cv. oolong no. 12)

In quadrant I, sample O12-GT-3 has high content of GCG, caffeine, cathecin, total catechins, EGCG, FRAP, TPC, and ECG. This sample has more various dominant chemical constituent than others. In quadrant II, sample O12-GT-7 has high content of EC and DPPH. Sample O12-GT-2 is close to variable DPPH. In quadrant III, there are sample O12-GT-6 and O12-GT-4. Both of them have high value in EGC. Sample O12-GT-5 and O12-GT-1 are in the same quadrant. Sample O12-GT-5 has high content of GC.

4.4.3. Principal Component of Oolong tea no. 12

The first principal component has variance (eigenvalue) 5.7745 and accounts for 44.4% of the total variance. The second principal component had variance 3.4282 and accounts for 26.4% of the data variability. Variables in the same quadrant are close, so they vary together at least within the 70.8% of the variation that the two components explain.

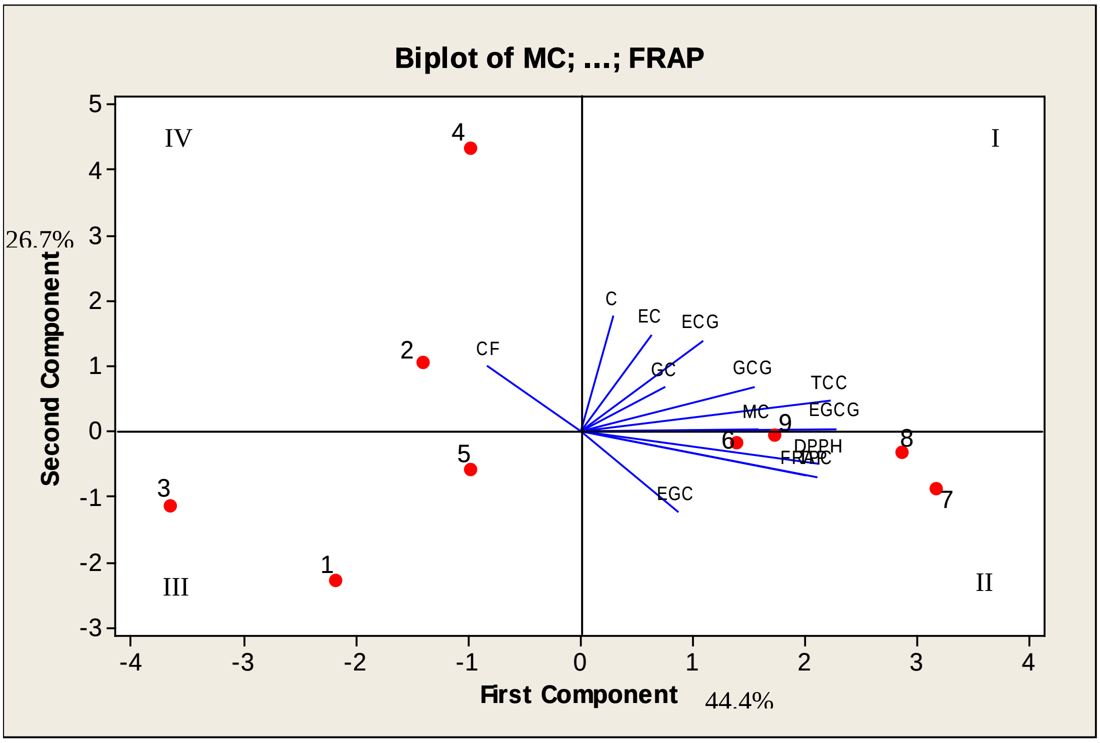


Figure 31 Biplot graph of oolong tea from cv. oolong no. 12

Variable EC, GC, MC, EGC, C, and caffeine has short vector, it means that the data diversity is small and data values are almost similar each other. Variable catechin, EC, ECG, GC, GCG, TCC, moisture content, and EGCG have positive correlation. Positive correlation are also found in variable DPPH, FRAP, TPC, and EGC.

Sample O12-OT-9 is close to variable DPPH and sample O12-OT-6 is close to variable FRAP. Sample O12-OT-8 and O12-OT-7have high value of antioxidant capacity in DPPH and FRAP, and content of TPC and EGC. Sample O12-OT-3, O12-OT-1, and O12-OT-5 are in quadrant III. But those samples are not close to any variables. In quadrant VI, sample O12-OT-2 and O12-OT-4 have content of caffeine more than mean.

4.4.4. Principal Component of Oolong tea no. 17

The first principal component has variance (eigenvalue) 4.9072 and accounts for 37.7% of the total variance. The second principal component had variance 3.3807 and accounts for 26% of the data variability. Variables in the same quadrant are close, so they vary together at least within the 63.7% of the variation that the two components explain.

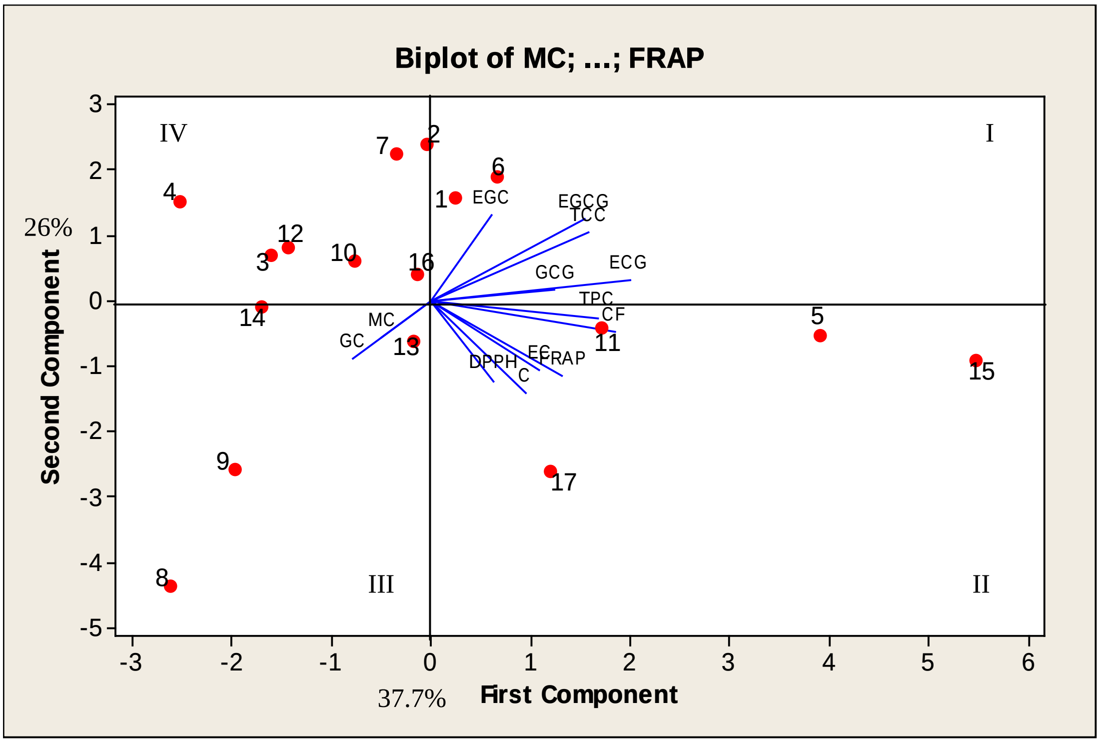


Figure 32 Biplot graph of oolong tea from cv. oolong no. 17

Variable MC, GC and DPPH have short vector, it means that the data diversity is small and data values are almost similar each other. Variable DPPH and FRAP are positively related to TPC, Caffeine, EC, and Catechin. So when one is high (relatively) for a sample, the other is low.

Sample O17-OT-1 and O17-OT-6 are in quadrant I. Both of them are close to variable EGC, EGCG, TCC, GCG, and ECG. In quadrant II, there are sample O17-OT-11, O17-OT-5, O17-OT-15, and O17-OT-017. Sample O17-OT-15 has the highest content of DPPH, EC, FRAP, TPC, caffeine among others, and followed by sample O17-OT-5 and O17-OT-017. Sample O17-OT-8, O17-OT-9, O17-OT-13, and O17-OT-14areonly close to variable moisture content and GC. In quadrant VI, there are sample O17-OT-2, O17-OT-3, O17-OT-4, O17-OT-7, O17-OT-10, O17-OT-12and O17-OT-16. Those samples are not close to any variables.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

This research is a contribution to the chemical characterization of green tea and oolong tea samples manufactured in Thailand. The obtained results suggest significant differences in the chemical constituents of various brands of green teas and oolong teas. In this research, 95% of the 39 tea samples showed a moisture content below 7%, 5% of tea samples being above 7%. The total polyphenol content of green tea was found to vary from 11.52 to 20.19% GAE, in oolong tea was found in a range of 10.22 to 17.57% GAE. These results were lower than green tea from China as the main producers of the world. The caffeine content in green tea samples were in a range of 1.69 to 3.71%, while in oolong tea samples were in a range of 1.61 to 3.26% w/w. These caffeine contents were similar to caffeine content of tea from China and Taiwan. The catechin content in green tea samples were in a range of 8.31 to 14.08 %, in oolong tea samples were in a range of 6.81 to 12.46% w/w. The antioxidant capacity of green tea samples was 164.01 mmole TE/ 100 g dry basis, in oolong tea samples was 132.73 mmole TE/ 100 g dry basis. These results were higher than those of other plants which are rich in antioxidants, such as strawberry, raspberry, broccoli and spinach. Antioxidant capacities of all tested teas had a correlation with the total polyphenol content, caffeine, total catechins content, catechin, EC and ECG.

5.2. Recommendations

Amino acids are one of the key components in tea. For further research, amino acids assay should be conducted to determine amino acids content in tea products manufactured in Thailand, because these components account for the freshness and briskness of the tea liquor. Other chemical constituents in tea that change during processing should be determined, such as chlorophyll, flavanols, and other volatile compounds.

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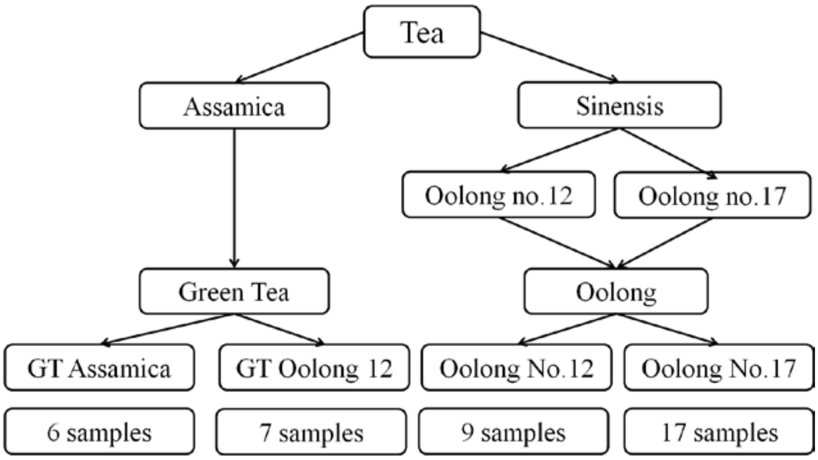
APPENDIX

Appendix 1. Tea samples



Appendix 2.Contents of moisture in green tea from var.*assamica*, green tea from cv. oolong no.12, oolong tea from cv. oolong no.12, and oolong tea fromvar.oolong no. 17

Code	MC (%w/w)
A-GT-1	4,88 ± 0,13 d
A-GT-2	5,77 ± 0,06 c
A-GT-3	4,70 ± 0,14 d
A-GT-4	5,98 ± 0,08 bc
A-GT-5	6,03 ± 0,08 b
A-GT-6	9,17 ± 0,06 a
min	4.88
max	9.17
Mean	6.09
SD	1.61
O12-GT-1	6.17 ± 0.02 b
O12-GT-2	5.51 ± 0.06 c
O12-GT-3	5.51 ± 0.02 c
O12-GT-4	4.80 ± 0.00 d
O12-GT-5	6.60 ± 0.01 a
O12-GT-6	4.29 ± 0.01 e
O12-GT-7	4.82 ± 0.08 d
min	4.29
max	6.60
Mean	5.38
SD	0.81
O12-OT-1	5.72 ± 0.10 c
O12-OT-2	2.88 ± 0.08 f
O12-OT-3	1.39 ± 0.04 g
O12-OT-4	4.78 ± 0.01 e
O12-OT-5	1.18 ± 0.05 c
O12-OT-6	5.28 ± 0.03 d
O12-OT-7	5.38 ± 0.03 d
O12-OT-8	6.33 ± 0.07 d
O12-OT-9	8.20 ± 0.08 a
min	1.18
max	8.20
Mean	8.23
SD	2.32
O17-OT-1	2.23 ± 0.08 de
O17-OT-2	6.05 ± 0.03 b
O17-OT-3	5.46 ± 0.15 c
O17-OT-4	2.19 ± 0.02 e
O17-OT-5	1.49 ± 0.01 g
O17-OT-6	2.30 ± 0.00 de
O17-OT-7	1.58 ± 0.08 g
O17-OT-8	5.54 ± 0.07 c
O17-OT-9	2.29 ± 0.07 de

Cont'd appendix 2

Code	MC (%w/w)
O17-OT-10	2.37 ± 0.09 d
O17-OT-11	1.47 ± 0.02 g
O17-OT-12	1.49 ± 0.05 g
O17-OT-13	5.58 ± 0.06 c
O17-OT-14	2.31 ± 0.03 de
O17-OT-15	1.84 ± 0.09 f
O17-OT-16	0.83 ± 0.02 h
O17-OT-017	6.28 ± 0.04 a
min	0.83
max	6.28
Mean	3.02
SD	1.89

Results are means ± SD (n (A-GT) = 6; n (O12-GT) = 7; n (O12-OT) = 9; n (O17-OT) = 17). For each column, values followed by the same letter are not statistically different at $P < 0.05$ as measured by the Duncan test.

Appendix 3 Contents of total polyphenol in green tea from var.*assamica*, green tea from var.*sinensis/*cv. oolong no.12, oolong tea from var.*sinensis/*cv. oolong no.12, and oolong tea from var.*sinensis/*oolong no. 17

Code	TPC (%w/w)
A-GT-1	20.02 ± 0,54 ab
A-GT-2	18.60 ± 0,25 c
A-GT-3	20.06 ± 0,92 ab
A-GT-4	21.19 ± 0,69 a
A-GT-5	18.93 ± 0,15 bc
A-GT-6	17.01 ± 0,45 d
Min	17.01
Max	21.19
Mean	19.30
SD	1.46
O12-GT-1	14.65 ± 0.63 d
O12-GT-2	15.41 ± 0.55 c
O12-GT-3	17.68 ± 0.53 a
O12-GT-4	14.03 ± 0.52 d
O12-GT-5	11.86 ± 0.10 e
O12-GT-6	14.24 ± 0.35 d
O12-GT-7	16.47 ± 0.53 b
Min	11.86
Max	17.68
Mean	14.90
SD	1.87
O12-OT-1	11.69± 0.61 de
O12-OT-2	12.48 ± 0.55 d
O12-OT-3	11.37 ± 0.20 e
O12-OT-4	10.22 ± 0.48 f
O12-OT-5	14.34 ± 0.23 c
O12-OT-6	15.17 ± 0.52 d
O12-OT-7	17.47 ± 0.33 d
O12-OT-8	17.57 ± 0.20 a
O12-OT-9	16.45 ± 0.46 b
Min	10.22
Max	17.57
Mean	14.08
SD	2.47
O17-OT-1	15.38 ± 0.34 bc
O17-OT-2	14.14 ± 0.12 defg
O17-OT-3	14.33 ± 0.28 def
O17-OT-4	13.32 ± 0.29 fgh
O17-OT-5	16.17 ± 0.37 ab
O17-OT-6	14.24 ± 0.08 def

Cont’d appendix 3

Code	TPC (%w/w)
O17-OT-7	14.82 ± 0.29 cde
O17-OT-8	15.46 ± 0.71 cdef
O17-OT-9	14.94 ± 0.56 efg
O17-OT-10	14.39 ± 0.68 fgh
O17-OT-11	16.24 ± 0.48 cd
O17-OT-12	14.22 ± 0.21 gh
O17-OT-13	14.96 ± 0.30 efg
O17-OT-14	13.42 ± 0.12 h
O17-OT-15	17.79 ± 0.64 a
O17-OT-16	13.52 ± 0.87 h
O17-OT-017	15.96 ± 0.77 cde
Min	11.55
Max	15.60
Mean	14.90
SD	1.11

Results are means ± SD (n (A-GT) = 6; n (O12-GT) = 7; n (O12-OT) = 9; n (O17-OT) = 17). For each column, values followed by the same letter are not statistically different at P < 0.05 as measured by the Duncan test.

Appendix 4 Antioxidant capacity in green tea from var.*assamica*, green tea from cv. oolong no.12, oolong tea from cv. oolong no.12, and oolong tea from cv.oolong no. 17

Code	**Antioxidant**	
	DPPH-assay (mmolTE/100g)	**FRAP-assay (mmolAA/100g)**
A-GT-1	247.10 ± 5.57 a	1.71 ± 0.13 d
A-GT-2	240.56 ± 4.62 a	1.48 ± 0.10 e
A-GT-3	150.69 ± 5.24 c	2.29 ± 0.16 b
A-GT-4	178.92 ± 6.48 b	2.51 ± 0.12 a
A-GT-5	153.80 ± 9.91 c	2.13 ± 0.16 c
A-GT-6	132.32 ± 5.80 d	1.92 ± 0.09 d
min	132.32	1.48
max	247.11	2.51
Mean	183.90	2.01
SD	48.79	0.33
O12-GT-1	119.35 ± 3.97 d	1.05 ± 0.26 cd
O12-GT-2	116.18 ± 3.37 de	1.16 ± 0.24 abc
O12-GT-3	147.34 ± 3.77 c	1.34 ± 0.15 a
O12-GT-4	111.80 ± 3.01 e	1.08 ± 0.09 bcd
O12-GT-5	80.08 ± 3.06 f	0.88 ± 0.10 d
O12-GT-6	212.64 ± 5.11 b	1.04 ± 0.10 cd
O12-GT-7	241.39 ± 7.10 a	1.26 ± 0.08 ab
min	80080.73	0.88
max	241387.59	1.34
Mean	146968.93	1.12
SD	58663.61	0.15
O12-OT-1	101.06 ± 6.07 c	1.48 ± 0.10 cd
O12-OT-2	113.74 ± 8.80 c	1.59 ± 0.11 bc
O12-OT-3	102.84 ± 11.49 c	1.40 ± 0.23 cd
O12-OT-4	98.93 ± 7.96 c	1.31 ± 0.15 d
O12-OT-5	131.11 ± 7.31 b	1.57 ± 0.04 bc
O12-OT-6	140.14 ± 5.32 ab	1.78 ± 0.01 ab
O12-OT-7	147.62 ± 9.28 a	1.95 ± 0.06 ab
O12-OT-8	147.05 ± 5.24 a	2.06 ± 0.05 a
O12-OT-9	135.41 ± 12.68 ab	1.93± 0.08 ab
min	98.93	1.31
max	147.62	2.06
Mean	124.21	1.67
SD	20.12	0.18
O17-OT-1	131.80 ± 2.26 efg	1.74 ± 0.05 bcdefg
O17-OT-2	124.12 ± 8.30 fg	1.68 ± 0.07 cdefg
O17-OT-3	123.32 ± 6.11 fg	1.65 ± 0.07 efg
O17-OT-4	105.35 ± 7.53 h	1.54 ± 0.02 g
O17-OT-5	117.84 ± 6.87	1.75 ± 0.08 bcdefg
O17-OT-6	121.63 ± 8.03 fg	1.65 ± 0.03 defg
O17-OT-7	123.38 ± 2.45 fg	1.56 ± 0.02 fg

Cont'd appendix 4

Code	Antioxidant	
	DPPH-assay (mmolTE/100g)	**FRAP-assay (mmolAA/100g)**
O17-OT-8	147.71 ± 10.86 bcd	1.69 ± 0.08 bcde
O17-OT-9	156.76 ± 2.43 abc	1.63 ± 0.05 bcdf
O17-OT-10	141.15 ± 15.69 de	1.54 ± 0.11 cdefg
O17-OT-11	163.03 ± 13.11 a	1.72 ± 0.07 bc
O17-OT-12	142.62 ± 7.65 cde	1.62 ± 0.17 bcdef
O17-OT-13	144.81 ± 5.31bcde	1.71 ± 0.04 bcd
O17-OT-14	131.14 ± 9.76 efg	1.50 ± 0.05 efg
O17-OT-15	164.61± 4.79 a	1.90 ± 0.08 a
O17-OT-16	134.17 ± 11.60 def	1.57 ± 0.04 cdefg
O17-OT-017	159.61 ± 6.75 ab	1.78 ± 0.09 ab
min	105.35	1.50
max	164.61	1.90
Mean	137.24	1.67
SD	17.28	0.11

Results are means ± SD (n (A-GT) = 6; n (O12-GT) = 7; n (O12-OT) = 9; n (O17-OT) = 17). For each column, values followed by the same letter are not statistically different at $P < 0.05$ as measured by the Duncan test.

Appendix 5 Content of caffeine in green tea from var.*assamica*, green tea from cv. oolong no.12, oolong tea from cv. oolong no.12, and oolong tea from cv.oolong no. 17

Code	**CF (% w/w)**
A-GT-1	3.71 ± 0.21
A-GT-2	3.43 ± 0.05
A-GT-3	3.44 ± 0.01
A-GT-4	3.35 ± 1.59
A-GT-5	3.27 ± 0.04
A-GT-6	3.45 ± 0.23
min	3.27
max	3.71
Mean	3.44
SD	0.35
O12-GT-1	2.54 ± 0.11 c
O12-GT-2	2.81 ± 0.27 b
O12-GT-3	3.17 ± 0.08 ab
O12-GT-4	1.69 ± 0.10 d
O12-GT-5	1.93 ± 0.36 d
O12-GT-6	1.82 ± 0.03 d
O12-GT-7	3.51 ± 0.07 a
min	1.69
max	3.51
Mean	2.50
SD	0.71
O12-OT-1	2.01 ± 0.26
O12-OT-2	2.97 ± 0.08
O12-OT-3	1.84 ± 0.01
O12-OT-4	3.26 ± 1.45
O12-OT-5	2.85 ± 0.08
O12-OT-6	2.33 ± 0.22
O12-OT-7	NP
O12-OT-8	2.48 ± 0.18
O12-OT-9	2.63 ± 0.08
min	1.84
max	3.26
Mean	2.55
SD	0.48
O17-OT-1	1.77 ± 0.01 fg
O17-OT-2	2.24 ± 0.00 cde
O17-OT-3	1.70 ± 0.14 fg
O17-OT-4	1.61 ± 0.14 g
O17-OT-5	3.25 ± 0.08 a
O17-OT-6	2.32 ± 0.09 cd
O17-OT-7	2.07 ± 0.01 def
O17-OT-8	2.04 ± 0.49 def

Cont’d appendix 5

Code	CF (% w/w)
O17-OT-9	1.88 ± 0.01 efg
O17-OT-10	1.99 ± 0.11 defg
O17-OT-11	2.28 ± 0.26 cd
O17-OT-12	1.94 ± 0.07 defg
O17-OT-13	2.49 ± 0.03 bc
O17-OT-14	2.24 ± 0.03 cde
O17-OT-15	3.18 ± 0.05 a
O17-OT-16	2.50 ± 0.16 bc
O17-OT-017	2.74 ± 0.23 b
min	1.61
max	3.25
Mean	2.25
SD	0.47

Results are means ± SD (n (A-GT) = 6; n (O12-GT) = 7; n (O12-OT) = 9; n (O17-OT) = 17). For each column, values followed by the same letter are not statistically different at $P < 0.05$ as measured by the Duncan test.

Appendix 6 Content of total catechins and single catechins in green tea from var.*assamica*, green tea from var.*sinensis/*cv. oolong no.12, oolong tea from var.*sinensis/*cv. oolong no.12, and oolong tea from var.*sinensis/*oolong no. 17

Code	TCC(% w/w)	GC (% w/w)	EGC (% w/w)	C (% w/w)	EC (% w/w)	EGCG (% w/w)	GCG (% w/w)	ECG(% w/w)	CG (% w/w)
A-GT-1	13.08 ± 1.11	0.77 ± 0.06	1.60 ± 0.36 b	1.70 ± 0.04	2.88±0.16 a	2.20 ± 0.61 cd	0.39 ± 0.08	3.53 ± 0.14 a	nd
A-GT-2	12.88 ± 0.90	1.01 ± 0.02	1.95 ± 0.00ab	1.51 ± 0.03	2.29 ± 0.05 ab	2.74 ± 0.05 bc	0.48 ± 0.04	2.90 ± 0.14 ab	nd
A-GT-3	13.51 ± 1.08	0.89 ± 0.56	1.70 ± 0.20 b	2.15 ± 0.13	2.62 ± 0.04 ab	2.44 ± 0.16 c	0.25 ± 0.02	3.45 ± 0.00 a	nd
A-GT-4	11.99 ± 0.98	0.99 ± 0.56	2.16 ± 0.19 ab	1.41 ± 0.95	1.31 ± 0.02 c	3.69 ± 0.92 ab	0.76 ± 0.58	1.65 ± 1.41 bc	nd
A-GT-5	14.11 ± 1.10	0.96 ± 0.03	2.48 ± 0.02 a	1.61 ± 0.01	2.39 ± 0.02 c	3.47 ± 0.06 a	0.34 ± 0.02	2.84 ± 0.04 c	nd
A-GT-6	8.98 ± 1.07	0.39 ± 0.03	0.70 ± 0.01 c	1.53 ± 0.05	1.87 ± 0.01 bc	1.16 ± 0.02 d	0.09 ± 0.17	3.24 ± 0.10 a	nd
min	8.98	0.39	0.70	1.41	1.31	1.16	0.09	1.65	-
Max	14.11	1.01	2.48	2.15	2.88	3.69	0.76	3.53	-
Mean	12.42	0.84	1.77	1.65	2.23	2.62	0.39	2.94	-
SD	1.83	0.24	0.61	0.26	0.56	0.92	0.22	0.69	-
O12-GT-1	10.99 ± 1.22 ab	1.13 ± 0.04 b	2.87 ± 0.41 a	0.90 ± 0.02 bc	0.95 ± 0.07 ab	3.74 ± 0.61 bc	0.76 ± 0.18 b	0.63 ± 0.01 c	nd
O12-GT-2	10.94 ± 1.35 c	0.91 ± 0.04 a	2.95 ± 0.18 b	0.87 ± 0.14 a	0.91 ± 0.08 b	4.01 ± 0.27 d	0.51 ± 0.10 bc	0.78 ± 0.06 b	nd
O12-GT-3	13.20 ± 1.67 a	0.91 ± 0.03 cd	2.41 ± 0.13 a	1.04 ± 0.01 b	1.09 ± 0.00 a	5.49 ± 0.29 ab	1.06 ± 0.11 a	1.19 ± 0.04 a	nd
O12-GT-4	10.32 ± 1.29 bc	1.08 ± 0.05 b	3.18 ± 0.56 a	0.64 ± 0.03 d	0.80 ± 0.01 bc	3.50 ± 0.63 bc	0.60 ± 0.13 bc	0.52 ± 0.03 d	nd
O12-GT-5	8.32 ± 0.90 c	0.99 ± 0.05 bc	2.17 ± 0.63 a	0.64 ± 0.00 d	0.70 ± 0.01 c	2.75 ± 0.85 c	0.66 ± 0.10 b	0.41 ± 0.06 e	nd
O12-GT-6	10.54 ± 1.38 bc	0.80 ± 0.01 de	3.16 ± 0.22 a	0.72 ± 0.04 cd	0.91 ± 0.03 b	3.83 ± 0.34 bc	0.36 ± 0.05 c	0.76 ± 0.02 b	nd
O12-GT-7	11.69 ± 1.44 ab	0.74 ± 0.14 e	2.50 ± 0.41 a	1.03 ± 0.07 b	1.09 ± 0.09 a	4.62 ± 0.30 a	0.58 ± 0.01 bc	1.12 ± 0.06 a	nd
Min	8.32	0.74	2.17	0.64	0.70	2.75	0.36	0.41	-

Cont'd appendix 6

Code	TCC(% w/w)	GC (% w/w)	EGC (% w/w)	C (% w/w)	EC (% w/w)	EGCG (% w/w)	GCG (% w/w)	ECG(% w/w)	CG (% w/w)
Max	13.20	1.13	3.18	1.04	1.09	5.49	1.06	1.19	-
Mean	10.86	0.94	2.75	0.83	0.92	3.99	0.65	0.77	-
SD	1.47	0.14	0.39	0.17	0.14	0.87	0.22	0.29	-
O12-OT-1	9.10 ± 1.20	0.95 ± 0.21	3.15 ± 0.17	0.45 ± 0.41	0.68 ± 0.17	2.91 ± 0.09	0.54 ± 0.12	0.42 ± 0.02	nd
O12-OT-2	9.46 ± 0.86	1.06 ± 0.14	2.21 ± 0.70	0.96 ± 0.19	0.95 ± 0.11	2.90 ± 1.15	0.83 ± 0.08	0.55 ± 0.03	nd
O12-OT-3	8.14 ± 0.93	0.89 ± 0.10	2.52 ± 0.49	0.74 ± 0.005	0.81 ± 0.02	2.46 ± 0.38	0.29 ± 0.06	0.42 ± 0.07	nd
O12-OT-4	11.17 ± 0.91	1.00 ± 0.51	2.00 ± 0.62	1.19 ± 0.75	1.23 ± 0.65	3.49 ± 1.80	0.87 ± 0.73	1.39 ± 1.35	nd
O12-OT-5	9.91 ± 1.91	0.91 ± 0.06	3.54 ± 0.48	0.68 ± 0.06	1.21 ± 0.15	2.61 ± 0.81	0.34 ± 0.06	0.61 ± 0.26	nd
O12-OT-6	11.01 ± 1.23	1.08 ± 0.07	2.79 ± 0.05	0.79 ± 0.16	0.92 ± 0.06	3.83 ± 0.01	0.84 ± 0.18	0.76 ± 0.03	nd
O12-OT-7	12.47 ± 1.61	0.89 ± 0.02	2.69 ± 0.04	0.74 ± 0.03	0.92 ± 0.03	5.01 ± 0.11	1.12 ± 0.002	1.00 ± 0.03	nd
O12-OT-8	12.47 ± 1.54	1.06 ± 0.03	3.61 ± 0.02	0.87 ± 0.12	1.05 ± 0.09	4.40 ± 0.01	0.61 ± 0.10	0.88 ± 0.03	nd
O12-OT-9	11.23 ± 1.28	1.00 ± 0.02	2.83 ± 0.27	0.82 ± 0.02	0.96 ±0.003	3.98 ± 0.02	0.95 ± 0.05	0.69 ± 0.02	nd
Min	8.14	0.89	2.00	0.45	0.68	2.46	0.29	0.42	-
Max	12.47	1.08	3.61	1.19	1.23	5.10	1.12	1.39	-
Mean	10.55	0.98	2.82	0.80	0.97	3.52	0.71	0.75	-
SD	1.50	0.07	0.55	0.20	0.18	0.88	0.28	0.31	-
O17-OT-1	11.44 ± 1.39 ab	1.47 ± 0.13 abcd	4.06 ± 0.22 a	0.70 ± 0.05 efg	0.99 ± 0.04 ef	3.09 ± 0.20 abcd	0.56 ± 0.01 def	0.57 ± 0.01 c	nd

Cont'd appendix 6

Code	TCC(% w/w)	GC (% w/w)	EGC (% w/w)	C (% w/w)	EC (% w/w)	EGCG (% w/w)	GCG (% w/w)	ECG(% w/w)	CG (% w/w)
O17-OT-2	10.85 ± 1.28 abcd	1.27 ± 0.02 ef	3.45 ± 0.06 ab	0.59 ± 0.06 g	0.84 ± 0.03 gh	3.33 ± 0.08 ab	0.82 ± 0.01 abcde	0.56 ± 0.00 c	nd
O17-OT-3	10.13 ± 1.15 bcde	1.44 ± 0.03 abcde	3.58 ± 0.13 ab	0.74 ± 0.06 defg	1.02 ± 0.04 cde	2.38 ± 0.06 de	0.53 ± 0.05 ef	0.44 ± 0.03 cd	nd
O17-OT-4	9.42 ± 1.05 cde	1.34 ± 0.17 cdef	3.30 ± 0.37 bc	0.73 ± 0.04 defg	1.01 ± 0.05 de	2.14 ± 0.45 e	0.46 ± 0.12 f	0.42 ± 0.11 cd	nd
O17-OT-5	10.45 ± 0.78 bcde	1.21 ± 0.01 f	2.20 ± 0.09 e	1.11 ± 0.07 a	1.16 ± 0.01 ab	2.96 ± 0.07 abcde	0.88 ± 0.05 abc	0.93 ± 0.05 a	nd
O17-OT-6	11.13 ± 1.16 ab	1.47 ± 0.04 abcde	3.20 ± 0.16 bcd	0.67 ± 0.09 efg	0.92 ± 0.05 efg	3.28 ± 0.17 abc	0.99 ± 0.03 a	0.60 ± 0.04 bc	nd
O17-OT-7	10.70 ± 1.19 abcd	1.45 ± 0.02 abcde	3.39 ± 0.01 abc	0.65 ± 0.05 fg	0.85 ± 0.02 fgh	3.03 ± 0.07 abcd	0.76 ± 0.04 abcdef	0.56 ± 0.02 c	nd
O17-OT-8	6.82 ± 0.45 g	1.61 ± 0.02 ab	1.35 ± 0.29 f	0.95 ± 0.04 abc	1.16 ± 0.11 abc	0.87 ± 0.88 f	0.62 ± 0.46 cdef	0.27 ± 0.35 d	nd
O17-OT-9	7.45 ± 0.45 fg	1.53 ± 0.06 abc	1.55 ± 0.40 f	0.91 ± 0.08 bcd	0.92 ± 0.07 efg	1.34 ± 0.59 f	0.71 ± 0.01 abcdef	0.48 ± 0.06 cd	nd
O17-OT-10	9.92 ± 1.00 bcde	1.34 ± 0.11 cdef	3.10 ± 0.05 bcd	0.80 ± 0.05 bcdef	0.95 ± 0.08 efg	2.51 ± 0.02 bcde	0.74 ± 0.05 abcdef	0.48 ± 0.05 cd	nd
O17-OT-11	10.98 ± 1.10 abc	1.44 ± 0.06 abcde	3.22 ± 0.23 bcd	0.87 ± 0.20 bcde	1.03 ± 0.13 bcde	3.05 ± 0.14 abcd	0.76 ± 0.12 abcdef	0.62 ± 0.00 bc	nd
O17-OT-12	9.40 ± 0.95 cde	1.43 ± 0.02 bcde	2.72 ± 0.48 cde	0.67 ± 0.12 fg	0.75 ± 0.01 h	2.60 ± 0.38 bcde	0.77 ± 0.04 abcdef	0.46 ± 0.03 cd	nd
O17-OT-13	9.20 ± 0.81 de	1.31 ± 0.04 def	2.53 ± 0.40 de	0.78 ± 0.07 cdefg	0.89 ± 0.04 efgh	2.35 ± 0.31 de	0.86 ± 0.02 abcd	0.48 ± 0.01 cd	nd
O17-OT-14	8.93 ± 0.73 ef	1.45 ± 0.03 abcde	2.38 ± 0.55 e	0.80 ± 0.01 bcdef	0.94 ± 0.05 efg	2.12 ± 0.49 e	0.78 ± 0.04 abcde	0.47 ± 0.05 cd	nd

Cont'd appendix 6

Code	TCC(% w/w)	GC (% w/w)	EGC (% w/w)	C (% w/w)	EC (% w/w)	EGCG (% w/w)	GCG (% w/w)	ECG(% w/w)	CG (% w/w)
O17-OT-15	12.35 ± 1.22 a	1.33 ± 0.05 def	3.46 ± 0.24 ab	0.96 ± 0.03 abc	1.22 ± 0.01 a	3.62 ± 0.11 a	0.95 ± 0.08 abcde	0.82 ± 0.12 ab	nd
O17-OT-16	9.31 ± 0.79 cde	1.22 ± 0.11 f	2.26 ± 0.40 e	0.91 ± 0.04 bcd	0.85 ± 0.00 fgh	2.62 ± 0.46 bcde	0.93 ± 0.06 abcdef	0.52 ± 0.07 c	nd
O17-OT-017	10.50 ± 0.95 bcde	1.62 ± 0.16 a	3.10 ± 0.15 bcd	0.99 ± 0.10 ab	1.14 ± 0.09 abcd	2.42 ± 0.12 cde	0.67 ± 0.09 bcdef	0.56 ± 0.04 c	nd
Min	6.82	0.02	0.01	0.05	0.02	0.07	0.04	0.02	-
Max	12.35	1.62	4.06	1.11	1.22	3.62	0.99	0.93	-
Mean	9.94	1.32	2.67	0.78	0.93	2.40	0.71	0.51	-
SD	1.39	0.36	1.00	0.23	0.27	0.92	0.23	0.20	-

Appendix 7. Mositure content raw data in dry basis and wet basis

Sample	% Moisture (%w/w)			% Dry matter(%w/w)			%moisture%w/w (db)		
	Mean	SD	%RSD	Mean	SD	%RSD	Mean	SD	%RSD
O12-GT-001	5.8099	0.0155	0.2663	94.1901	0.0155	0.0164	6.1683	0.0174	0.2827
O12-GT-002	5.2242	0.0582	1.1140	94.7758	0.0582	0.0614	5.5122	0.0648	1.1754
O12-GT-003	5.2206	0.0206	0.3947	94.7794	0.0206	0.0217	5.5082	0.0229	0.4164
O12-GT-004	4.5752	0.0042	0.0915	95.4248	0.0042	0.0044	4.7946	0.0046	0.0958
O12-GT-005	6.1883	0.0062	0.1007	93.8117	0.0062	0.0066	6.5965	0.0071	0.1074
O12-GT-006	4.1166	0.0113	0.2740	95.8834	0.0113	0.0118	4.2933	0.0123	0.2858
O12-GT-007	4.5996	0.0713	1.5499	95.4004	0.0713	0.0747	4.8214	0.0783	1.6246
A-GT-001	4.6528	0.1148	2.4675	95.3472	0.1148	0.1204	4.8799	0.1263	2.5879
A-GT-002	5.4582	0.0548	1.0047	94.5418	0.0548	0.0580	5.7734	0.0614	1.0627
A-GT-003	4.4919	0.1245	2.7719	95.5081	0.1245	0.1304	4.7032	0.1365	2.9022
A-GT-004	5.6454	0.0735	1.3011	94.3546	0.0735	0.0778	5.9832	0.0825	1.3789
A-GT-005	5.6867	0.0754	1.3256	94.3133	0.0754	0.0799	6.0297	0.0848	1.4056
A-GT-006	8.4037	0.0510	0.6070	91.5963	0.0510	0.0557	9.1748	0.0608	0.6627
O17-OT-001	2.1836	0.0732	3.3545	97.8164	0.0732	0.0749	2.2324	0.0766	3.4293
O17-OT-002	5.7057	0.0258	0.4524	94.2943	0.0258	0.0274	6.0510	0.0290	0.4797
O17-OT-003	5.1781	0.1372	2.6502	94.8219	0.1372	0.1447	5.4610	0.1526	2.7948

Cont'd appendix 7

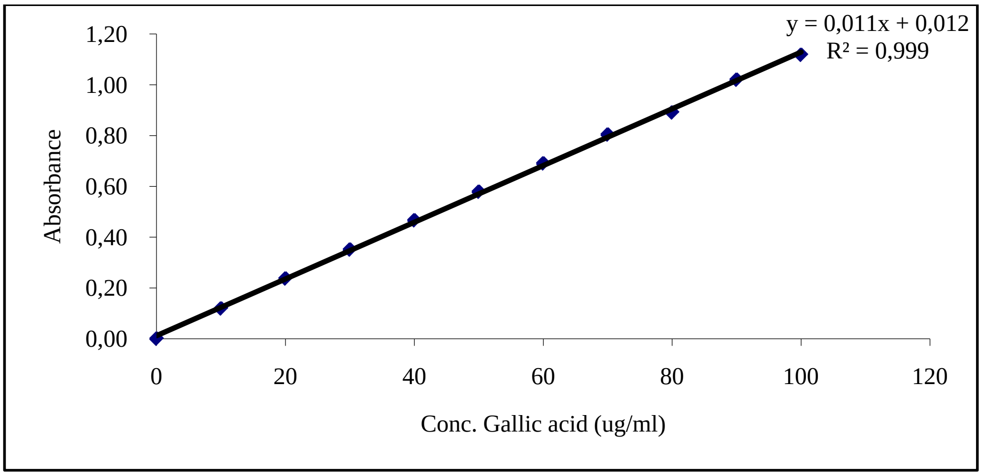
Sample	% Moisture (%w/w)			% Dry matter(%w/w)			%moisture%w/w (db)		
	Mean	SD	%RSD	Mean	SD	%RSD	Mean	SD	%RSD
O17-OT-004	2.1434	0.0198	0.9249	97.8566	0.0198	0.0203	2.1903	0.0207	0.9451
O17-OT-005	1.4638	0.0110	0.7492	98.5362	0.0110	0.0111	1.4856	0.0113	0.7603
O17-OT-006	2.2526	0.0031	0.1396	97.7474	0.0031	0.0032	2.3045	0.0033	0.1428
O17-OT-007	1.5534	0.0757	4.8741	98.4466	0.0757	0.0769	1.5780	0.0781	4.9509
O17-OT-008	5.2533	0.0652	1.2418	94.7467	0.0652	0.0689	5.5446	0.0727	1.3106
O17-OT-009	2.2377	0.0679	3.0360	97.7623	0.0679	0.0695	2.2889	0.0711	3.1055
O17-OT-010	2.3126	0.0870	3.7609	97.6874	0.0870	0.0890	2.3674	0.0911	3.8499
O17-OT-011	1.4494	0.0182	1.2543	98.5506	0.0182	0.0184	1.4707	0.0187	1.2728
O17-OT-012	1.4689	0.0476	3.2385	98.5311	0.0476	0.0483	1.4908	0.0490	3.2867
O17-OT-013	5.2863	0.0534	1.0109	94.7137	0.0534	0.0564	5.5814	0.0596	1.0673
O17-OT-014	2.2612	0.0258	1.1409	97.7388	0.0258	0.0264	2.3135	0.0270	1.1673
O17-OT-015	1.8037	0.0878	4.8674	98.1963	0.0878	0.0894	1.8368	0.0910	4.9567
O17-OT-016	0.8189	0.0156	1.9065	99.1811	0.0156	0.0157	0.8257	0.0159	1.9222
O17-OT-017	5.9080	0.0396	0.6702	94.0920	0.0396	0.0421	6.2790	0.0447	0.7123
O12-OT-001	5.4096	0.0915	1.6907	94.5904	0.0915	0.0967	5.7190	0.1022	1.7874
O12-OT-002	2.7972	0.0756	2.7011	97.2028	0.0756	0.0777	2.8777	0.0800	2.7788
O12-OT-003	1.3734	0.0373	2.7185	98.6266	0.0373	0.0379	1.3926	0.0384	2.7563
O12-OT-004	4.5646	0.0124	0.2717	95.4354	0.0124	0.0130	4.7829	0.0136	0.2847
O12-OT-005	1.1686	0.0499	4.2709	98.8314	0.0499	0.0505	1.1824	0.0511	4.3213

Cont'd appendix 7

Sample	% Moisture (%w/w)			% Dry matter(%w/w)			%moisture%w/w (db)		
	Mean	SD	%RSD	Mean	SD	%RSD	Mean	SD	%RSD
O12-OT-006	5.0166	0.0235	0.4675	94.9834	0.0235	0.0247	5.2815	0.0260	0.4922
O12-OT-007	5.1085	0.0234	0.4587	94.8915	0.0234	0.0247	5.3835	0.0260	0.4834
O12-OT-008	5.9519	0.0637	1.0710	94.0481	0.0637	0.0678	6.3285	0.0721	1.1388
O12-OT-009	7.5776	0.0701	0.9248	92.4224	0.0701	0.0758	8.1989	0.0820	1.0006

Appendix 8. Gallic acid calibration curve

Con(µg/ml).	Abs.1	Abs.2	Abs.3	A spectro	A	SD
0	0.0076	0.0184	0.0088	0.0116	0.0000	0.0059
10	0.1352	0.1238	0.1326	0.1305	0.1189	0.0060
20	0.2429	0.2534	0.2491	0.2485	0.2369	0.0053
30	0.3620	0.3579	0.3677	0.3625	0.3509	0.0049
40	0.4649	0.4910	0.4774	0.4778	0.4662	0.0131
50	0.5953	0.5784	0.5971	0.5903	0.5787	0.0103
60	0.7005	0.7024	0.7028	0.7019	0.6903	0.0012
70	0.8211	0.8143	0.8109	0.8154	0.8038	0.0052
80	0.8867	0.9156	0.9048	0.9024	0.8908	0.0146
90	1.0407	1.0208	1.0326	1.0314	1.0198	0.0100
100	1.1609	1.1348	1.0925	1.13	1.1178	0.0345

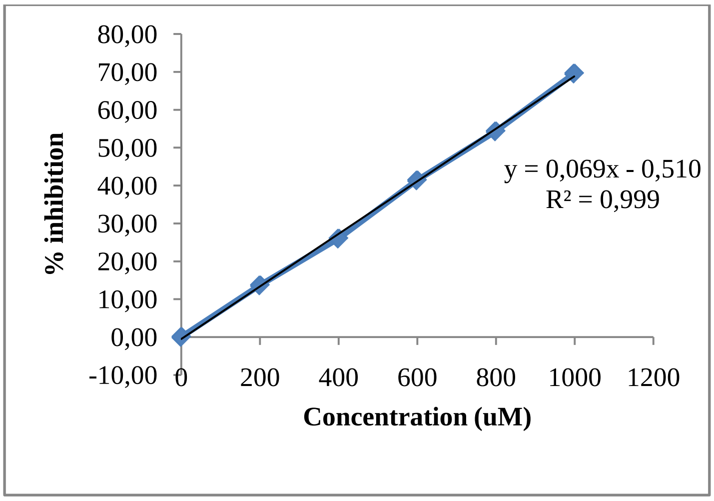


Appendix 9. DPPH-assay callibration curve (trolox standard)

Name	MW	Weight (g)	Vol. MeOH (ml)	Con. (mM)
Trolox	250.32	0.0250	10	9987.22
DPPH	394	0.0024	100	60.91

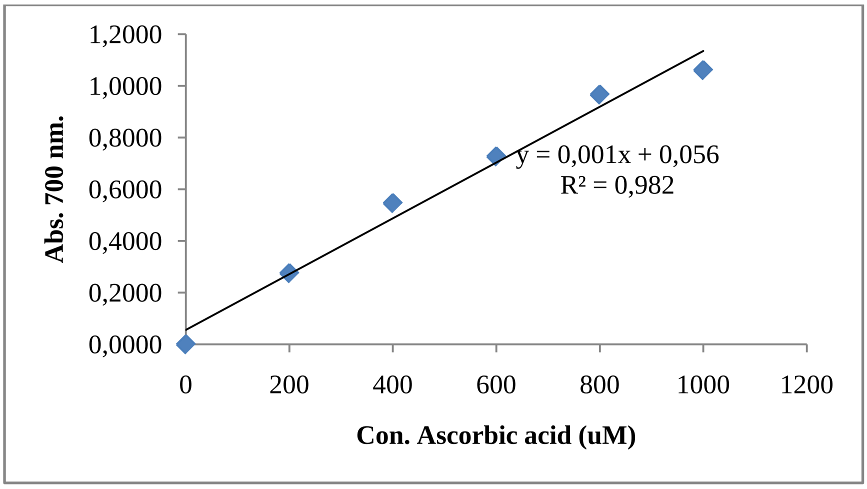
Standard trolox

Level	Con. (mM)	A 517				%Inhibition
		1	2	3	mean	
1	0	0.8309	0.8156	0.8224	0.8230	0.00
2	200	0.7138	0.6983	0.7200	0.7107	13.65
3	399	0.6084	0.5959	0.6231	0.6091	25.99
4	599	0.4561	0.5045	0.4870	0.4825	41.37
5	799	0.3803	0.3594	0.3885	0.3761	54.31
6	999	0.2681	0.2395	0.2437	0.2504	69.57



Appendix 10. Standard curve for Ferric reducing antioxidant power

Con.	Abs.1	Abs.2	Abs.3	A spectro	A	SD
0	0.0866	0.0825	0.0715	0.0802	0.0000	0.0078
200	0.3487	0.3456	0.3718	0.3554	0.2752	0.0143
400	0.6379	0.5952	0.6458	0.6263	0.5461	0.0272
600	0.8194	0.8276	0.7739	0.8070	0.7268	0.0289
800	1.0522	1.0655	1.0206	1.0461	0.9659	0.0231
1000	1.0881	1.1701	1.1637	1.1406	1.0604	0.0456

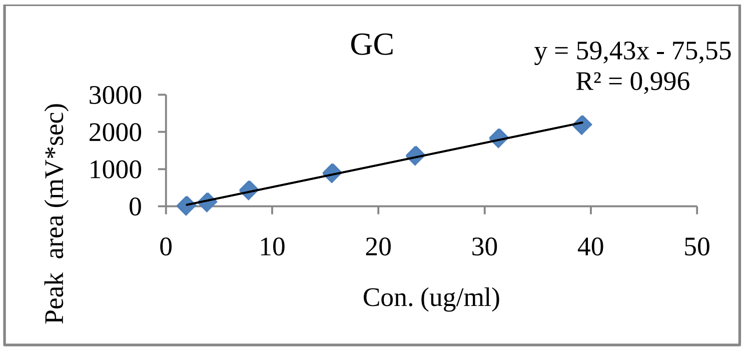


Appendix11. Data of Concentration Caffeine and Catechin in Mix Standard

Concentration										
Con.Mix	G	GC	EGC	C	EC	EGCG	CF	GCG	ECG	CG
(µg/mL)	99.9	39.2	40.18	100	97	80	100	40.18	98	49
1	0.20	0.08	0.08	0.20	0.19	0.16	0.20	0.08	0.20	0.10
2	1.00	0.39	0.40	1.00	0.97	0.80	1.00	0.40	0.98	0.49
3	5.00	1.96	2.01	5.00	4.85	4.00	5.00	2.01	4.90	2.45
4	9.99	3.92	4.02	10.00	9.70	8.00	10.00	4.02	9.80	4.90
5	19.98	7.84	8.04	20.00	19.40	16.00	20.00	8.04	19.60	9.80
6	39.96	15.68	16.07	40.00	38.80	32.00	40.00	16.07	39.20	19.60
7	59.94	23.52	24.11	60.00	58.20	48.00	60.00	24.11	58.80	29.40
8	79.92	31.36	32.14	80.00	77.60	64.00	80.00	32.14	78.40	39.20
9	99.90	39.20	40.18	100.00	97.00	80.00	100.00	40.18	98.00	49.00

Appendix12. Data and Curve of Gallocatechin standard

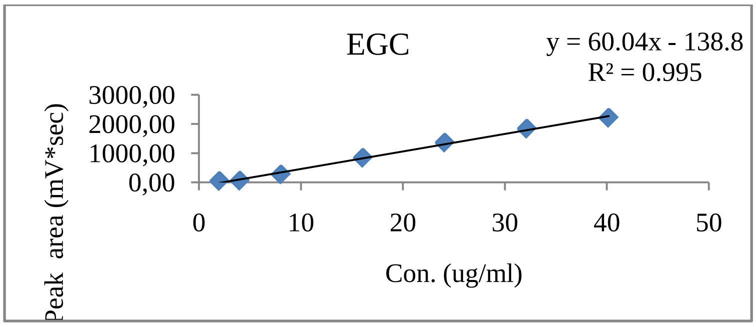
GC									
Level	Conc (µg/mL)	Peak area (mV*sec) 1	2	3	Mean	SD	%RSD	Peak area (mV*sec)	RF-GC
3	1.96	13472	9022	14117	12204	2774.2	22.73262	12.20	0.160607
4	3.92	117960	98942	99996	105633	10688.8	10.11882	105.63	0.037110
5	7.84	433241	428290	425265	428932	4026.6	0.93874	428.93	0.018278
6	15.68	889802	891797	886389	889329	2734.8	0.30751	889.33	0.017631
7	23.52	1361222	1361419	1354988	1359210	3657.4	0.26908	1359.21	0.017304
8	31.36	1811274	1870638	1809024	1830312	34941.5	1.90904	1830.31	0.017134
9	39.20	2131986	2127202	2292481	2183890	94073.3	4.30760	2183.89	0.017950



Appendix 13. Data and Curve of Epigallocatechin Standard

EGC

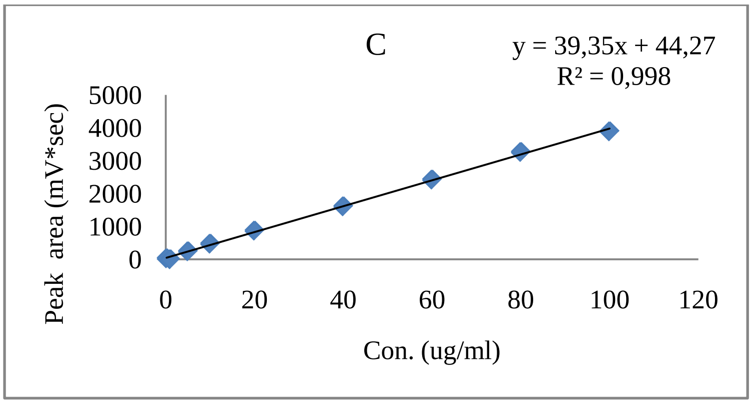
Level	Conc (μg/mL)	Peak area (mV*sec) 1	2	3	Mean	SD	%RSD	Peak area (mV*sec)	RFE-EGC
3	2.01	46516	45031	39105	43551	3921.0	9.00332	43.55	0.046130
4	4.02	60674	54821	51140	55545	4808.1	8.65615	55.55	0.072338
5	8.04	277513	272498	267033	272348	5241.6	1.92460	272.35	0.029506
6	16.07	846070	838482	838159	840904	4477.1	0.53241	840.90	0.019113
7	24.11	1363869	1366317	1361497	1363894	2410.1	0.17671	1363.89	0.017676
8	32.14	1818552	1878280	1818431	1838421	34519.0	1.87764	1838.42	0.017485
9	40.18	2150500	2153638	2333291	2212476	104640.3	4.72956	2212.48	0.018161



Appendix 14. Data and Curve of Catechin Standard

C

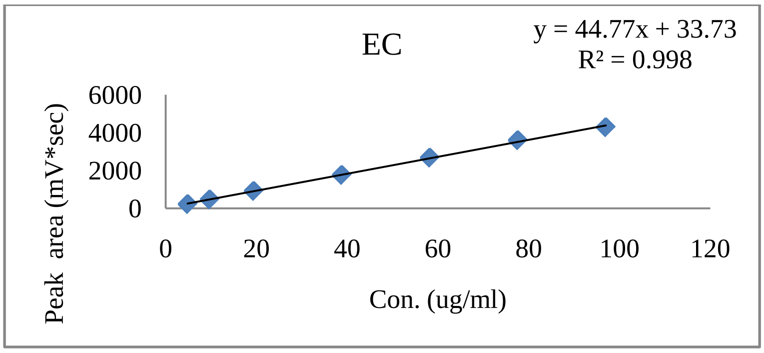
Level	Conc (µg/mL)	Peak area (mV*sec) 1	2	3	Mean	SD	%RSD	Peak area (mV*sec)	RF-C
1	0.20	46661	45593	7427	33227	22349.8	67.26408	33.23	0.006019
2	1.00	4381	4718	3579	4226	585.1	13.84539	4.23	0.236630
3	5.00	258152	249477	231391	246340	13653.5	5.542547	246.34	0.020297
4	10.00	496033	462270	474490	477598	17094.7	3.579307	477.60	0.020938
5	20.00	871562	880836	873651	875350	4864.8	0.55575	875.35	0.022848
6	40.00	1613818	1616021	1613928	1614589	1241.4	0.076884	1614.59	0.024774
7	60.00	2425475	2430889	2429159	2428508	2765.1	0.113862	2428.51	0.024707
8	80.00	3225592	3355028	3222453	3267691	75652.3	2.315162	3267.69	0.024482
9	100.00	3805808	3815782	4067067	3896219	148042.7	3.799651	3896.22	0.025666



Appendix 15. Data and Curve of Epicatechin Standard

EC

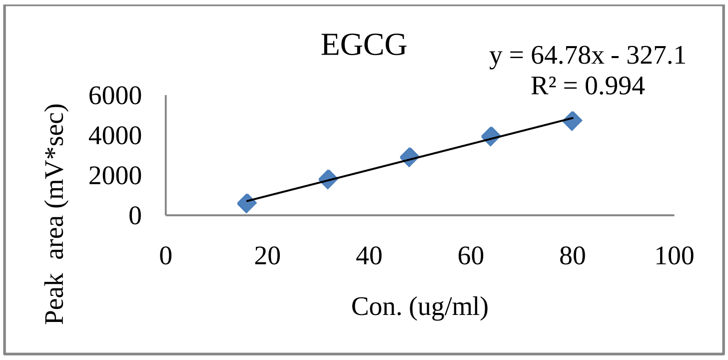
Level	Conc (µg/mL)	Peak area (mV*sec) 1	2	3	Mean	SD	%RSD	Peak area (mV*sec)	RF-EC
3	4.85	229877	219701	205325	218301	12335.7	5.650788	218.30	0.022217
4	9.70	483862	449854	458421	464046	17688.0	3.811684	464.05	0.020903
5	19.40	913945	916884	906668	912499	5259.3	0.576358	912.50	0.021260
6	38.80	1762054	1760126	1758253	1760144	1900.6	0.107978	1760.14	0.022044
7	58.20	2672613	2678775	2676645	2676011	3129.5	0.116948	2676.01	0.021749
8	77.60	3555755	3690704	3549852	3598770	79671.6	2.213856	3598.77	0.021563
9	97.00	4200623	4204674	4453436	4286244	144806.4	3.378398	4286.24	0.022631



Appendix 16. Data and Curve of Epigallocatechin gallate Standard

EGCG

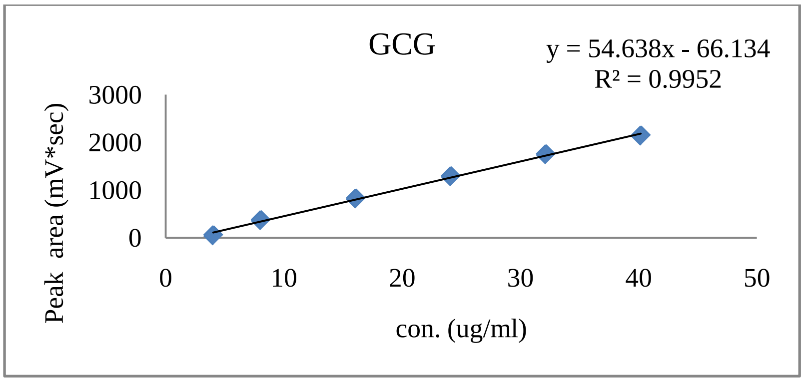
Level	Conc	Peak area (mV*sec)				SD	%RSD	Peak area	RF-
	(µg/mL)	1	2	3	Mean			(mV*sec)	EGCG
5	16.00	602610	596321	573670	590867	15221.4	2.57611	590.87	0.027079
6	32.00	1795609	1791354	1785725	1790896	4957.9	0.276839	1790.90	0.017868
7	48.00	2896843	2893573	2895324	2895247	1636.4	0.056519	2895.25	0.016579
8	64.00	3884732	4016829	3894688	3932083	73560.8	1.870785	3932.08	0.016276
9	80.00	4627886	4646375	4833889	4702717	113974.1	2.42358	4702.72	0.017011



Appendix 17. Data and Curve of Gallocatechine gallate standard

GCG

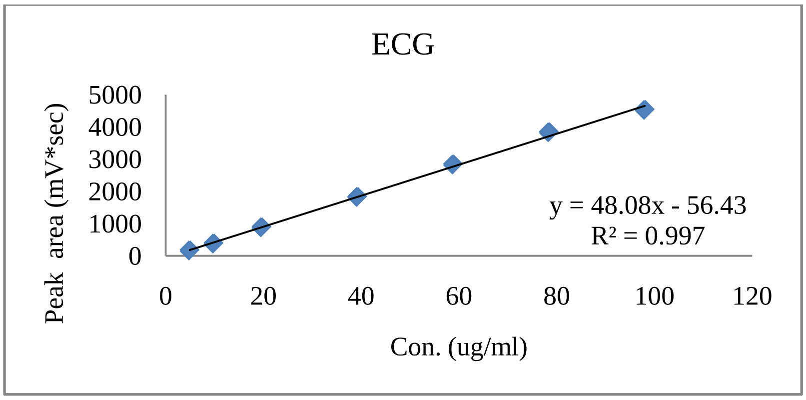
Level	Conc (μg/mL)	Peak area (mV*sec) 1	2	3	Mean	SD	%RSD	Peak area (mV*sec)	RF-GCG
4	4.02	56960	49114	49144	51739.3	4521.3	8.738526	51.74	0.077659
5	8.04	372415	375248	360921	369528	7587.3	2.053235	369.53	0.021747
6	16.07	823357	823338	819065	821920	2472.5	0.300823	821.92	0.019554
7	24.11	1284788	1285181	1296132	1288700	6439.0	0.499652	1288.70	0.018707
8	32.14	1729687	1789176	1728673	1749179	34642.4	1.980496	1749.18	0.018377
9	40.18	2073892	2078048	2270978	2140973	112607.1	5.259623	2140.97	0.018767



Appendix 18. Data and Curve of Epicatechin gallate Standard

ECG

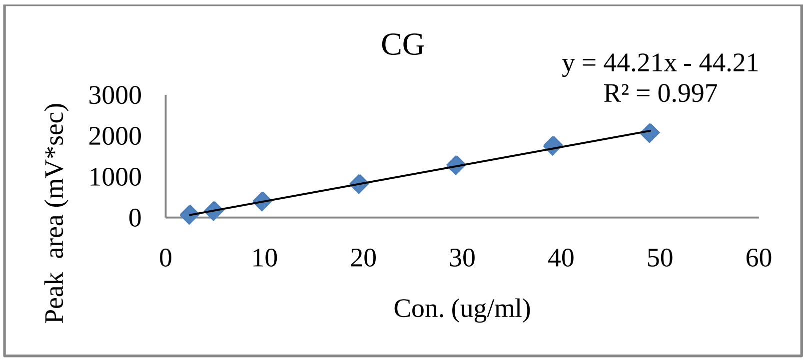
Level	Conc (µg/mL)	Peak area (mV*sec) 1	2	3	Mean	SD	%RSD	Peak area (mV*sec)	RF-ECG
3	4.90	170443	163453	160687	164861	5028.1	3.049899	164.86	0.029722
4	9.80	386359	372909	377111	378793	6880.9	1.816546	378.79	0.025872
5	19.60	886511	887579	877589	883893	5485.5	0.620604	883.89	0.022175
6	39.20	1832457	1819321	1826645	1826141	6582.5	0.360459	1826.14	0.021466
7	58.80	2834437	2835000	2832846	2834094	1117.1	0.039418	2834.09	0.020747
8	78.40	3791078	3929398	3783514	3834663	82129.8	2.141772	3834.66	0.020445
9	98.00	4506252	4511335	4565129	4527572	32624.5	0.720573	4527.57	0.021645



Appendix 19. Data and Curve of Catechin Gallate Standard

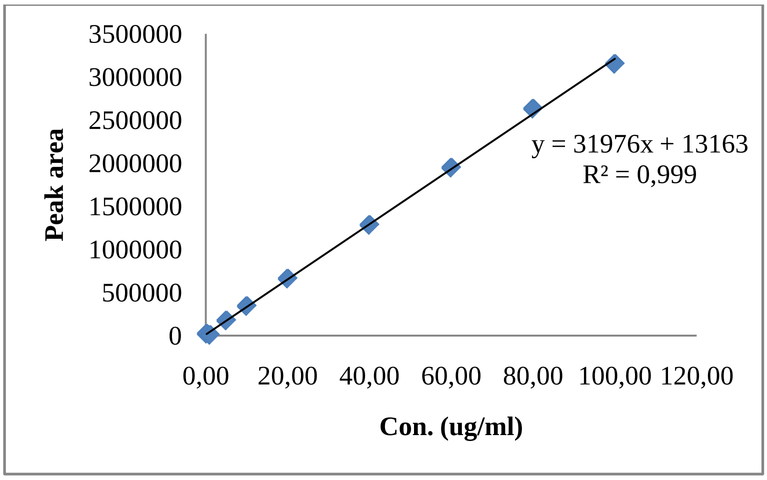
CG

Level	Conc (μg/mL)	Peak area (mV*sec) 1	2	3	Mean	SD	%RSD	Peak area (mV*sec)	RF-CG
3	2.45	65801	62792	58652	62415	3589.4	5.750829	62.42	0.039253
4	4.90	158481	151682	153876	154680	3470.0	2.243356	154.68	0.031678
5	9.80	390771	398559	379321	389550	9676.9	2.484124	389.55	0.025157
6	19.60	821299	812873	814387	816186	4491.9	0.550358	816.19	0.024014
7	29.40	1274066	1278920	1276134	1276373	2435.8	0.19084	1276.37	0.023034
8	39.20	1720236	1808215	1729822	1752758	48266.0	2.75372	1752.76	0.022365
9	49.00	2052642	2072100	2065152	2063298	9860.6	0.477905	2063.30	0.023748



Appendix 20. Data and Curve of Caffeine Standard

Peak area (mV*sec) 1	2	3	Mean	SD	%RSD	Peak area (mV*sec)	RF-CF	RF-CF Grubb's test
35046		32729	22592	1638.4	7.252083	22.59	0.008853	0.028437
8610	8833	8264	8569	286.7	3.345865	8.57	0.116700	0.029131
182649	177241	167583	175824	7632.3	4.3408404	175.82	0.028437	0.030235
357352	332481	339993	343275	12756.3	3.7160407	343.28	0.029131	0.031146
662590	668568	653289	661482	7699.5	1.1639752	661.48	0.030235	0.030795
1284839	1284653	1283294	1284262	843.5	0.0656763	1284.26	0.031146	0.030387
1946767	1948628	1949767	1948387	1514.4	0.0777264	1948.39	0.030795	0.031724
2605219	2693547	2599419	2632728	52750	2.0036357	2632.73	0.030387	
3089850	3094222	3272598	3152223	104270.4	3.3078378	3152.22	0.031724	
				Total				**0.030265**



Appendix 21. Grubb test of respon factor

Before Grubb's test

Lev	RF G	GC	EGC	C	EC	EGCG	CF	GCG	ECG	CG
3	0.015909	0.160607	0.046130	0.020297	0.022217	0.394251	0.028437	0.036873	0.029722	0.039253
4	0.019441	0.037110	0.072338	0.020938	0.020903	0.027079	0.029131	0.077659	0.025872	0.031678
5	0.021137	0.018278	0.029506	0.022848	0.021260	0.017868	0.030235	0.021747	0.022175	0.025157
6	0.023356	0.017631	0.019113	0.024774	0.022044	0.016579	0.031146	0.019554	0.021466	0.024014
7	0.023789	0.017304	0.017676	0.024707	0.021749	0.016276	0.030795	0.018707	0.020747	0.023034
8	0.023688	0.017134	0.017485	0.024482	0.021563	0.017011	0.030387	0.018377	0.020445	0.022365
9	0.025729	0.017950	0.018161	0.025666	0.022631		0.031724	0.018767	0.021645	0.023748

After Grubb's test

No.	RF G	GC	EGC	C	EC	EGCG	CF	GCG	ECG	CG
1	0.019441	0.018278	0.019113	0.020297	0.022217	0.017868	0.028437	0.021747	0.025872	0.025157
2	0.021137	0.017631	0.017676	0.020938	0.020903	0.016579	0.029131	0.019554	0.022175	0.024014
3	0.023356	0.017304	0.017485	0.022848	0.021260	0.016276	0.030235	0.018707	0.021466	0.023034
4	0.023789	0.017134	0.018161	0.024774	0.022044	0.017011	0.031146	0.018377	0.020747	0.022365
5	0.023688	0.017950		0.024707	0.021749		0.030795	0.018767	0.020445	0.023748
6	0.025729			0.024482	0.021563		0.030387		0.021645	
7				0.025666	0.022631		0.031724			
Mean	0.022856	0.017659	0.018108	0.023387	0.021767	0.016934	0.030265	0.019430	0.022058	0.023664

Analysis	RF
EGC	0.018108
C	0.023387
EC	0.021767
EGCG	0.016934
CF	0.030265
GCG	0.019430
ECG	0.022058
CG	0.023664

Appendix 22. Example of calculation of catechin and caffeine

Sample O12-GT-1

Sample weight (g)	REP.	%DM	Final Vol (ml)	DF	Rf-i	RF-CF	RF-i/RF-CF	std CF		Peak area (mV*sec)		Amount(g/100 g dry basis)		Aanalysis	SD
								slope	y-intercept	Peak area	Mean	Amount	Mean		
2	1	94.19	250	10	0.02	0.03	0.76	31976.00	13163.00	413526	448521.50	1.25	1.36	G	0.16
2	2	94.19	250	10	0.02	0.03	0.76	31976.00	13163.00	483517		1.47			
2	1	94.19	250	10	0.02	0.03	0.58	31976.00	13163.00	468115	480460.00	1.10	1.13	GC	0.04
2	2	94.19	250	10	0.02	0.03	0.58	31976.00	13163.00	492805		1.16			
2	1	94.19	250	10	0.02	0.03	0.60	31976.00	13163.00	1287828	1169269.00	3.16	2.87	EGC	0.41
2	2	94.19	250	10	0.02	0.03	0.60	31976.00	13163.00	1050764		2.58			
2	1	94.19	250	10	0.02	0.03	0.77	31976.00	13163.00	288221	293246.00	0.88	0.90	C	0.02
2	2	94.19	250	10	0.02	0.03	0.77	31976.00	13163.00	298271		0.91			
2	1	94.19	250	10	0.02	0.03	0.72	31976.00	13163.00	316502	332436.00	0.90	0.95	EC	0.07
2	2	94.19	250	10	0.02	0.03	0.72	31976.00	13163.00	348370		1.00			
2	1	94.19	250	10	0.02	0.03	0.56	31976.00	13163.00	1809827	1623132.5	4.17	3.74	EGCG	0.61
2	2	94.19	250	10	0.02	0.03	0.56	31976.00	13163.00	1436438		3.31			
2	1	94.19	250	10	0.03	0.03	1.00	31976.00	13163.00	643127	624573.00	2.61	2.54	CF	0.11
2	2	94.19	250	10	0.03	0.03	1.00	31976.00	13163.00	606019		2.46			
2	1	94.19	250	10	0.02	0.03	0.64	31976.00	13163.00	346999	300220.00	0.89	0.76	GCG	0.18
2	2	94.19	250	10	0.02	0.03	0.64	31976.00	13163.00	253441		0.64			
2	1	94.19	250	10	0.02	0.03	0.73	31976.00	13163.00	220037	222203.50	0.63	0.63	ECG	0.01
2	2	94.19	250	10	0.02	0.03	0.73	31976.00	13163.00	224370		0.64			
2	1	94.19	250	10	0.02	0.03	0.78	31976.00	13163.00	11427	6807.00	-0.01	-0.02	CG	0.02
2	2	94.19	250	10	0.02	0.03	0.78	31976.00	13163.00	2187		-0.04			

Appendix 23. ANOVA and Posthoc test of sample A-GT

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moist	Between Groups	26.029	5	5.206	550.392	.000
	Within Groups	.057	6	.009		
	Total	26.086	11			
tpc	Between Groups	21.153	5	4.231	13.618	.003
	Within Groups	1.864	6	.311		
	Total	23.017	11			
CAFFEINE	Between Groups	.220	5	.044	.101	.988
	Within Groups	2.614	6	.436		
	Total	2.834	11			
TCC	Between Groups	33.166	5	6.633	1.282	.380
	Within Groups	31.040	6	5.173		
	Total	64.206	11			
GC	Between Groups	.555	5	.111	2.103	.196
	Within Groups	.317	6	.053		
	Total	.872	11			
EGC	Between Groups	3.760	5	.752	21.325	.001
	Within Groups	.212	6	.035		
	Total	3.971	11			
C	Between Groups	.690	5	.138	.900	.536
	Within Groups	.920	6	.153		
	Total	1.610	11			
EC	Between Groups	3.160	5	.632	4.377	.050
	Within Groups	.866	6	.144		
	Total	4.026	11			
ECGC	Between Groups	8.432	5	1.686	8.152	.012
	Within Groups	1.241	6	.207		
	Total	9.673	11			
GCG	Between Groups	.295	4	.074	1.056	.464
	Within Groups	.349	5	.070		
	Total	.644	9			
ECG	Between Groups	4.736	5	.947	2.780	.123
	Within Groups	2.044	6	.341		
	Total	6.780	11			
DPPH	Between Groups	23799.380	5	4759.876	167.541	.000
	Within Groups	170.461	6	28.410		
	Total	23969.840	11			
FRAP	Between Groups	1.447	5	.289	109.899	.000
	Within Groups	.016	6	.003		
	Total	1.463	11			

Moist

Duncan

Sample	N	Subset for alpha = 0.05			
		1	2	3	4
A-GT-3	2	4.7050			
A-GT-1	2	4.8800			
A-GT-2	2		5.7750		
A-GT-4	2		5.9800	5.9800	
A-GT-5	2			6.0300	
A-GT-6	2				9.1750
Sig.		.122	.080	.626	1.000

Means for groups in homogeneous subsets are displayed.

CAFFEINE

Duncan

Sample	N	Subset for alpha = 0.05
		1
A-GT-5	2	3.2708
A-GT-4	2	3.3461
A-GT-2	2	3.4284
A-GT-3	2	3.4444
A-GT-6	2	3.4512
A-GT-1	2	3.7090
Sig.		.543

Means for groups in homogeneous subsets are displayed.

tpc

Duncan

Sample	N	Subset for alpha = 0.05			
		1	2	3	4
A-GT-6	2	17.0050			
A-GT-2	2		18.5950		
A-GT-5	2		18.9300	18.9300	
A-GT-1	2			20.0200	20.0200
A-GT-3	2			20.0650	20.0650
A-GT-4	2				21.1900
Sig.		1.000	.570	.097	.089

Means for groups in homogeneous subsets are displayed.

TCC

Duncan

Sample	N	Subset for alpha = 0.05
		1
A-GT-6	2	9.0000
A-GT-4	2	11.9799
A-GT-2	2	12.8894
A-GT-1	2	13.0700
A-GT-3	2	13.5050
A-GT-5	2	14.1150
Sig.		.079

Means for groups in homogeneous subsets are displayed.

GC

Duncan

Sample	N	Subset for alpha = 0.05	
		1	2
A-GT-6	2	.3901	
A-GT-1	2	.7707	.7707
A-GT-3	2	.8939	.8939
A-GT-5	2	.9600	.9600
A-GT-4	2		.9981
A-GT-2	2		1.0083
Sig.		.057	.360

Means for groups in homogeneous subsets are displayed.

C

Duncan

Sample	N	Subset for alpha = 0.05
		1
A-GT-4	2	1.4119
A-GT-2	2	1.5124
A-GT-6	2	1.5294
A-GT-5	2	1.6150
A-GT-1	2	1.6990
A-GT-3	2	2.1511
Sig.		.124

Means for groups in homogeneous subsets are displayed.

EGC

Duncan

Sample	N	Subset for alpha = 0.05			
		1	2	3	4
A-GT-6	2	.6991			
A-GT-1	2		1.5969		
A-GT-3	2		1.6979	1.6979	
A-GT-2	2		1.9515	1.9515	
A-GT-4	2			2.1623	2.1623
A-GT-5	2				2.4850
Sig.		1.000	.118	.054	.137

Means for groups in homogeneous subsets are displayed.

EC

Duncan

Sample	N	Subset for alpha = 0.05		
		1	2	3
A-GT-4	2	1.3135		
A-GT-6	2	1.8663	1.8663	
A-GT-2	2		2.2905	2.2905
A-GT-5	2		2.3950	2.3950
A-GT-3	2		2.6205	2.6205
A-GT-1	2			2.8813
Sig.		.196	.108	.188

Means for groups in homogeneous subsets are displayed.

ECGC

Duncan

Sample	N	Subset for alpha = 0.05			
		1	2	3	4
A-GT-6	2	1.1622			
A-GT-1	2	2.1999	2.1999		
A-GT-3	2		2.4405	2.4405	
A-GT-2	2		2.7396	2.7396	2.7396
A-GT-5	2			3.4700	3.4700
A-GT-4	2				3.6902
Sig.		.063	.295	.072	.090

Means for groups in homogeneous subsets are displayed.

GCG

Duncan

Sample	N	Subset for alpha = 0.05
		1
A-GT-3	2	.2517
A-GT-5	2	.3450
A-GT-1	2	.3945
A-GT-2	2	.4786
A-GT-4	2	.7555
Sig.		.126

Means for groups in homogeneous subsets are displayed.

ECG

Duncan

Sample	N	Subset for alpha = 0.05	
		1	2
A-GT-4	2	1.6546	
A-GT-5	2	2.8450	2.8450
A-GT-2	2	2.9023	2.9023
A-GT-6	2		3.2436
A-GT-3	2		3.4516
A-GT-1	2		3.5329
Sig.		.085	.303

Means for groups in homogeneous subsets are displayed.

DPPH

Duncan

Sample	N	Subset for alpha = 0.05			
		1	2	3	4
A-GT-6	2	1.3232E2			
A-GT-3	2		1.5069E2		
A-GT-5	2		1.5380E2		
A-GT-4	2			1.7892E2	
A-GT-2	2				2.4056E2
A-GT-1	2				2.4710E2
Sig.		1.000	.581	1.000	.265

Means for groups in homogeneous subsets are displayed.

FRAP

Duncan

Sample	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
A-GT-2	2	1.4850					
A-GT-1	2		1.7100				
A-GT-6	2			1.9250			
A-GT-5	2				2.1300		
A-GT-3	2					2.2950	
A-GT-4	2						2.5150
Sig.		1.000	1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Appendix 24. ANOVA and posthoc test of sample O12-GT

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moist	Between Groups	7.945	6	1.324	838.807	.000
	Within Groups	.011	7	.002		
	Total	7.956	13			
tpc	Between Groups	41.898	6	6.983	85.786	.000
	Within Groups	.570	7	.081		
	Total	42.468	13			
Caffeine	Between Groups	6.054	6	1.009	30.063	.000
	Within Groups	.235	7	.034		
	Total	6.289	13			
TCC	Between Groups	26.039	6	4.340	4.719	.031
	Within Groups	6.438	7	.920		
	Total	32.477	13			
GC	Between Groups	.239	6	.040	9.525	.004
	Within Groups	.029	7	.004		
	Total	.268	13			
EGC	Between Groups	1.837	6	.306	1.858	.218
	Within Groups	1.154	7	.165		
	Total	2.991	13			
C	Between Groups	.347	6	.058	14.613	.001
	Within Groups	.028	7	.004		
	Total	.374	13			
EC	Between Groups	.246	6	.041	14.344	.001
	Within Groups	.020	7	.003		
	Total	.265	13			
ECGC	Between Groups	9.040	6	1.507	5.666	.019
	Within Groups	1.862	7	.266		
	Total	10.902	13			
GCG	Between Groups	.591	6	.099	8.493	.006
	Within Groups	.081	7	.012		
	Total	.673	13			

		Sum of Squares	df	Mean Square	F	Sig.
ECG	Between Groups	1.011	6	.169	84.188	.000
	Within Groups	.014	7	.002		
	Total	1.025	13			
DPPH	Between Groups	41299.120	6	6883.187	903.996	.000
	Within Groups	53.299	7	7.614		
	Total	41352.419	13			
FRAP	Between Groups	.280	6	.047	6.804	.012
	Within Groups	.048	7	.007		
	Total	.328	13			

Moist

Duncan

sample	N	Subset for alpha = 0.05				
		1	2	3	4	5
O12-GT-6	2	4.2900				
O12-GT-4	2		4.7950			
O12-GT-7	2		4.8250			
O12-GT-3	2			5.5050		
O12-GT-2	2			5.5150		
O12-GT-1	2				6.1700	
O12-GT-5	2					6.5950
Sig.		1.000	.475	.809	1.000	1.000

Means for groups in homogeneous subsets are displayed.

tpc

Duncan

sample	N	Subset for alpha = 0.05				
		1	2	3	4	5
O12-GT-5	2	11.8550				
O12-GT-4	2		14.0350			
O12-GT-6	2		14.2400			
O12-GT-1	2		14.6500			
O12-GT-2	2			15.4150		
O12-GT-7	2				16.4700	
O12-GT-3	2					17.6750
Sig.		1.000	.077	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Caffeine

Duncan

sample	N	Subset for alpha = 0.05			
		1	2	3	4
O12-GT-4	2	1.6873			
O12-GT-6	2	1.8237			
O12-GT-5	2	1.9259			
O12-GT-1	2		2.5367		
O12-GT-2	2		2.8096	2.8096	
O12-GT-3	2			3.1734	3.1734
O12-GT-7	2				3.5145
Sig.		.250	.180	.087	.105

Means for groups in homogeneous subsets are displayed.

TCC

Duncan

sample	N	Subset for alpha = 0.05		
		1	2	3
O12-GT-5	2	8.3245		
O12-GT-4	2	10.3222	10.3222	
O12-GT-6	2	10.5388	10.5388	
O12-GT-2	2		10.9450	10.9450
O12-GT-1	2		10.9859	10.9859
O12-GT-7	2		11.6864	11.6864
O12-GT-3	2			13.2036
Sig.		.062	.222	.062

Means for groups in homogeneous subsets are displayed.

GC

Duncan

sample	N	Subset for alpha = 0.05			
		1	2	3	4
O12-GT-7	2	.7422			
O12-GT-6	2	.7965	.7965		
O12-GT-3	2		.9097	.9097	
O12-GT-2	2		.9133	.9133	
O12-GT-5	2			.9927	.9927
O12-GT-4	2				1.0774
O12-GT-1	2				1.1313
Sig.		.430	.126	.256	.078

Means for groups in homogeneous subsets are displayed.

C

Duncan

sample	N	Subset for alpha = 0.05			
		1	2	3	4
O12-GT-5	2	.6366			
O12-GT-4	2	.6445			
O12-GT-6	2	.7226	.7226		
O12-GT-2	2		.8703	.8703	
O12-GT-1	2			.8980	.8980
O12-GT-7	2				1.0292
O12-GT-3	2				1.0403
Sig.		.229	.051	.673	.066

Means for groups in homogeneous subsets are displayed.

EGC

Duncan

sample	N	Subset for alpha = 0.05
		1
O12-GT-5	2	2.1724
O12-GT-3	2	2.4132
O12-GT-7	2	2.4966
O12-GT-1	2	2.8699
O12-GT-2	2	2.9475
O12-GT-6	2	3.1612
O12-GT-4	2	3.1801
Sig.		.055

Means for groups in homogeneous subsets are displayed.

EC

Duncan

sample	N	Subset for alpha = 0.05			
		1	2	3	4
O12-GT-5	2	.6991			
O12-GT-4	2	.8033	.8033		
O12-GT-2	2		.9059	.9059	
O12-GT-6	2		.9120	.9120	
O12-GT-1	2			.9527	
O12-GT-3	2				1.0917
O12-GT-7	2				1.0920
Sig.		.092	.091	.427	.997

Means for groups in homogeneous subsets are displayed.

ECGC

Duncan

sample	N	Subset for alpha = 0.05		
		1	2	3
O12-GT-5	2	2.7491		
O12-GT-4	2	3.4945	3.4945	
O12-GT-1	2	3.7373	3.7373	
O12-GT-6	2	3.8298	3.8298	
O12-GT-2	2	4.0100	4.0100	
O12-GT-7	2		4.6181	4.6181
O12-GT-3	2			5.4902
Sig.		.057	.081	.135

Means for groups in homogeneous subsets are displayed.

ECG

Duncan

sample	N	Subset for alpha = 0.05				
		1	2	3	4	5
O12-GT-5	2	.4136				
O12-GT-4	2		.5244			
O12-GT-1	2			.6321		
O12-GT-6	2				.7589	
O12-GT-2	2				.7847	
O12-GT-7	2					1.1237
O12-GT-3	2					1.1872
Sig.		1.000	1.000	1.000	.582	.199

Means for groups in homogeneous subsets are displayed.

GCG

Duncan

sample	N	Subset for alpha = 0.05		
		1	2	3
O12-GT-6	2	.3578		
O12-GT-2	2	.5093	.5093	
O12-GT-7	2	.5847	.5847	
O12-GT-4	2	.5953	.5953	
O12-GT-5	2		.6565	
O12-GT-1	2		.7646	
O12-GT-3	2			1.0625
Sig.		.076	.063	1.000

Means for groups in homogeneous subsets are displayed.

DPPH

Duncan

sample	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
O12-GT-5	2	80.0800					
O12-GT-4	2		1.1180E2				
O12-GT-2	2		1.1618E2	1.1618E2			
O12-GT-1	2			1.1935E2			
O12-GT-3	2				1.4734E2		
O12-GT-6	2					2.1264E2	
O12-GT-7	2						2.4139E2
Sig.		1.000	.157	.288	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

FRAP

Duncan

sample	N	Subset for alpha = 0.05			
		1	2	3	4
O12-GT-5	2	.8800			
O12-GT-6	2	1.0400	1.0400		
O12-GT-1	2	1.0500	1.0500		
O12-GT-4	2	1.0800	1.0800	1.0800	
O12-GT-2	2		1.1600	1.1600	1.1600
O12-GT-7	2			1.2600	1.2600
O12-GT-3	2				1.3400
Sig.		.057	.212	.075	.075

Means for groups in homogeneous subsets are displayed.

Appendix 25. ANOVA and posthoc test of sample O12-OT

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moist	Between Groups	86.443	8	10.805	2.929E3	.000
	Within Groups	.033	9	.004		
	Total	86.476	17			
tpc	Between Groups	122.248	8	15.281	113.300	.000
	Within Groups	1.214	9	.135		
	Total	123.462	17			
TCC	Between Groups	35.290	8	4.411	.894	.557
	Within Groups	44.406	9	4.934		
	Total	79.696	17			
GC	Between Groups	.103	8	.013	.341	.928
	Within Groups	.341	9	.038		
	Total	.444	17			
EGC	Between Groups	4.013	8	.502	3.121	.055
	Within Groups	1.446	9	.161		
	Total	5.459	17			
C	Between Groups	.632	8	.079	.880	.566
	Within Groups	.808	9	.090		
	Total	1.441	17			
EC	Between Groups	.416	8	.052	.928	.536
	Within Groups	.504	9	.056		
	Total	.919	17			
ECGC	Between Groups	11.024	8	1.378	2.303	.118
	Within Groups	5.386	9	.598		
	Total	16.410	17			
GCG	Between Groups	1.329	8	.166	2.458	.101
	Within Groups	.608	9	.068		
	Total	1.937	17			
ECG	Between Groups	1.505	8	.188	.897	.556
	Within Groups	1.888	9	.210		
	Total	3.393	17			

		Sum of Squares	df	Mean Square	F	Sig.
DPPH	Between Groups	6475.903	8	809.488	20.004	.000
	Within Groups	364.193	9	40.466		
	Total	6840.096	17			
FRAP	Between Groups	1.121	8	.140	18.089	.000
	Within Groups	.070	9	.008		
	Total	1.190	17			
Caffeine	Between Groups	3.289	7	.470	1.663	.245
	Within Groups	2.260	8	.283		
	Total	5.549	15			

Moist

Duncan

Sample	N	Subset for alpha = 0.05							
		1	2	3	4	5	6	7	8
O12-OT-5	2	1.1850							
O12-OT-3	2		1.3950						
O12-OT-2	2			2.8750					
O12-OT-4	2				4.7800				
O12-OT-6	2					5.2800			
O12-OT-7	2					5.3850			
O12-OT-1	2						5.7200		
O12-OT-8	2							6.3300	
O12-OT-9	2								8.2000
Sig.		1.000	1.000	1.000	1.000	.118	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

tpc

Duncan

Sample	N	Subset for alpha = 0.05						
		1	2	3	4	5	6	7
O12-OT-4	2	10.2150						
O12-OT-3	2		11.3650					
O12-OT-1	2		11.6850	11.6850				
O12-OT-2	2			12.4800				
O12-OT-5	2				14.3350			
O12-OT-6	2					15.1700		
O12-OT-9	2						16.4450	
O12-OT-7	2							17.4700
O12-OT-8	2							17.5700
Sig.		1.000	.406	.059	1.000	1.000	1.000	.792

Means for groups in homogeneous subsets are displayed.

TCC

Duncan

Sample	N	Subset for alpha = 0.05
		1
O12-OT-3	2	8.1400
O12-OT-1	2	9.0950
O12-OT-2	2	9.4650
O12-OT-5	2	10.1750
O12-OT-6	2	11.0000
O12-OT-4	2	11.1700
O12-OT-9	2	11.2350
O12-OT-7	2	12.4650
O12-OT-8	2	12.4700
Sig.		.109

Means for groups in homogeneous subsets are displayed.

GC

Duncan

Sample	N	Subset for alpha = 0.05
		1
O12-OT-5	2	.8656
O12-OT-3	2	.8912
O12-OT-7	2	.8941
O12-OT-1	2	.9544
O12-OT-4	2	1.0001
O12-OT-9	2	1.0031
O12-OT-8	2	1.0581
O12-OT-2	2	1.0605
O12-OT-6	2	1.0759
Sig.		.339

Means for groups in homogeneous subsets are displayed.

GC

Duncan

Sample	N	Subset for alpha = 0.05		
		1	2	3
O12-OT-4	2	2.0037		
O12-OT-2	2	2.2087	2.2087	
O12-OT-3	2	2.5205	2.5205	
O12-OT-7	2	2.6921	2.6921	2.6921
O12-OT-6	2	2.7878	2.7878	2.7878
O12-OT-9	2	2.8332	2.8332	2.8332
O12-OT-1	2		3.1475	3.1475
O12-OT-5	2		3.2073	3.2073
O12-OT-8	2			3.6058
Sig.		.091	.050	.067

Means for groups in homogeneous subsets are displayed.

EC

Duncan

Sample	N	Subset for alpha = 0.05
		1
O12-OT-1	2	.6786
O12-OT-3	2	.8116
O12-OT-6	2	.9173
O12-OT-7	2	.9199
O12-OT-2	2	.9495
O12-OT-9	2	.9601
O12-OT-8	2	1.0482
O12-OT-5	2	1.1053
O12-OT-4	2	1.2324
Sig.		.063

Means for groups in homogeneous subsets are displayed.

C

Duncan

Sample	N	Subset for alpha = 0.05
		1
O12-OT-1	2	.4532
O12-OT-5	2	.7168
O12-OT-7	2	.7382
O12-OT-3	2	.7419
O12-OT-6	2	.7860
O12-OT-9	2	.8211
O12-OT-8	2	.8701
O12-OT-2	2	.9644
O12-OT-4	2	1.1872
Sig.		.054

Means for groups in homogeneous subsets are displayed.

ECGC

Duncan

Sample	N	Subset for alpha = 0.05	
		1	2
O12-OT-3	2	2.4635	
O12-OT-2	2	2.8973	
O12-OT-1	2	2.9087	
O12-OT-5	2	3.1870	3.1870
O12-OT-4	2	3.4894	3.4894
O12-OT-6	2	3.8325	3.8325
O12-OT-9	2	3.9777	3.9777
O12-OT-8	2	4.3963	4.3963
O12-OT-7	2		5.0959
Sig.		.050	.051

Means for groups in homogeneous subsets are displayed.

GCG

Duncan

Sample	N	Subset for alpha = 0.05		
		1	2	3
O12-OT-3	2	.2924		
O12-OT-5	2	.3041	.3041	
O12-OT-1	2	.5378	.5378	.5378
O12-OT-8	2	.6060	.6060	.6060
O12-OT-2	2	.8340	.8340	.8340
O12-OT-6	2	.8434	.8434	.8434
O12-OT-4	2	.8710	.8710	.8710
O12-OT-9	2		.9487	.9487
O12-OT-7	2			1.1208
Sig.		.073	.051	.072

Means for groups in homogeneous subsets are displayed.

ECG

Duncan

Sample	N	Subset for alpha = 0.05
		1
O12-OT-1	2	.4162
O12-OT-3	2	.4179
O12-OT-2	2	.5472
O12-OT-9	2	.6907
O12-OT-6	2	.7643
O12-OT-5	2	.7938
O12-OT-8	2	.8836
O12-OT-7	2	1.0041
O12-OT-4	2	1.3858
Sig.		.086

Means for groups in homogeneous subsets are displayed.

DPPH

Duncan

Sample	N	Subset for alpha = 0.05		
		1	2	3
O12-OT-4	2	98.9300		
O12-OT-1	2	1.0106E2		
O12-OT-3	2	1.0284E2		
O12-OT-2	2	1.1374E2		
O12-OT-5	2		1.3112E2	
O12-OT-9	2		1.3541E2	1.3541E2
O12-OT-6	2		1.4014E2	1.4014E2
O12-OT-8	2			1.4705E2
O12-OT-7	2			1.4762E2
Sig.		.057	.207	.106

Means for groups in homogeneous subsets are displayed.

FRAP

Duncan

Sample	N	Subset for alpha = 0.05				
		1	2	3	4	5
O12-OT-4	2	1.3150				
O12-OT-3	2	1.4000	1.4000			
O12-OT-1	2	1.4800	1.4800			
O12-OT-5	2		1.5750	1.5750		
O12-OT-2	2		1.5900	1.5900		
O12-OT-6	2			1.7800	1.7800	
O12-OT-9	2				1.9300	1.9300
O12-OT-7	2				1.9500	1.9500
O12-OT-8	2					2.0600
Sig.		.106	.074	.053	.097	.191

Means for groups in homogeneous subsets are displayed.

caffeine

Duncan

sample	N	Subset for alpha = 0.05	
		1	2
O12-OT-3	2	1.8350	
O12-OT-1	2	2.0100	2.0100
O12-OT-6	2	2.3250	2.3250
O12-OT-8	2	2.4800	2.4800
O12-OT-9	2	2.6250	2.6250
O12-OT-5	2	2.8550	2.8550
O12-OT-2	2	2.9700	2.9700
O12-OT-4	2		3.2650
Sig.		.085	.062

Means for groups in homogeneous subsets are displayed.

Appendix 26. ANOVA and posthoc test of sample O12-GT

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moist	Between Groups	114.736	16	7.171	1.642E3	.000
	Within Groups	.074	17	.004		
	Total	114.811	33			
tpc	Between Groups	44.253	16	2.766	12.952	.000
	Within Groups	3.630	17	.214		
	Total	47.884	33			
Caffeine	Between Groups	7.126	16	.445	16.365	.000
	Within Groups	.463	17	.027		
	Total	7.588	33			
TCC	Between Groups	61.958	16	3.872	7.649	.000
	Within Groups	8.607	17	.506		
	Total	70.565	33			
GC	Between Groups	.462	16	.029	4.467	.002
	Within Groups	.110	17	.006		
	Total	.572	33			
EGC	Between Groups	17.239	16	1.077	12.419	.000
	Within Groups	1.475	17	.087		
	Total	18.714	33			
C	Between Groups	.649	16	.041	6.195	.000
	Within Groups	.111	17	.007		
	Total	.760	33			
EC	Between Groups	.555	16	.035	9.201	.000
	Within Groups	.064	17	.004		
	Total	.619	33			
ECGC	Between Groups	15.877	16	.992	7.849	.000
	Within Groups	2.149	17	.126		
	Total	18.027	33			
GCG	Between Groups	.706	16	.044	2.741	.023
	Within Groups	.274	17	.016		
	Total	.980	33			

		Sum of Squares	df	Mean Square	F	Sig.
ECG	Between Groups	.725	16	.045	4.484	.002
	Within Groups	.172	17	.010		
	Total	.897	33			
DPPH	Between Groups	9554.926	16	597.183	14.048	.000
	Within Groups	722.678	17	42.510		
	Total	10277.604	33			
FRAP	Between Groups	.334	16	.021	3.216	.011
	Within Groups	.110	17	.006		
	Total	.444	33			

Moist

Duncan

Sample	N	Subset for alpha = 0.05							
		1	2	3	4	5	6	7	8
O17-OT-16	2	.8250							
O17-OT-11	2		1.4700						
O17-OT-5	2		1.4850						
O17-OT-12	2		1.4950						
O17-OT-7	2		1.5750						
O17-OT-15	2			1.8350					
O17-OT-4	2				2.1900				
O17-OT-1	2				2.2350	2.2350			
O17-OT-9	2				2.2900	2.2900			
O17-OT-6	2				2.3050	2.3050			
O17-OT-14	2				2.3100	2.3100			
O17-OT-10	2					2.3650			
O17-OT-3	2						5.4600		
O17-OT-8	2						5.5450		
O17-OT-13	2						5.5800		
O17-OT-2	2							6.0500	
O17-OT-17	2								6.2800
Sig.		1.000	.162	1.000	.119	.093	.102	1.000	1.000

Means for groups in homogeneous subsets are displayed.

tpc

Duncan

Sample	N	Subset for alpha = 0.05						
		1	2	3	4	5	6	7
O17-OT-4	2	13.3200						
O17-OT-14	2	13.4150						
O17-OT-16	2	13.5150						
O17-OT-2	2	14.1400	14.1400					
O17-OT-12	2	14.2150	14.2150					
O17-OT-6	2	14.2400	14.2400					
O17-OT-3	2	14.3300	14.3300	14.3300				
O17-OT-10	2	14.3900	14.3900	14.3900	14.3900			
O17-OT-7	2		14.8200	14.8200	14.8200			
O17-OT-9	2		14.9350	14.9350	14.9350	14.9350		
O17-OT-13	2		14.9600	14.9600	14.9600	14.9600		
O17-OT-1	2			15.3800	15.3800	15.3800	15.3800	
O17-OT-8	2				15.4600	15.4600	15.4600	
O17-OT-17	2					15.9600	15.9600	
O17-OT-5	2						16.1700	
O17-OT-11	2						16.2400	
O17-OT-15	2							17.7900
Sig.		.058	.137	.058	.054	.060	.110	1.000

Means for groups in homogeneous subsets are displayed.

Caffeine

Duncan

Sample	N	Subset for alpha = 0.05						
		1	2	3	4	5	6	7
O17-OT-4	2	1.6092						
O17-OT-3	2	1.6984	1.6984					
O17-OT-1	2	1.7739	1.7739					
O17-OT-9	2	1.8767	1.8767	1.8767				
O17-OT-12	2	1.9415	1.9415	1.9415	1.9415			
O17-OT-10	2	1.9881	1.9881	1.9881	1.9881			
O17-OT-8	2		2.0424	2.0424	2.0424			
O17-OT-7	2		2.0697	2.0697	2.0697			
O17-OT-2	2			2.2361	2.2361	2.2361		
O17-OT-14	2			2.2422	2.2422	2.2422		
O17-OT-11	2				2.2754	2.2754		
O17-OT-6	2				2.3204	2.3204		
O17-OT-13	2					2.4891	2.4891	
O17-OT-16	2					2.4987	2.4987	
O17-OT-17	2						2.7376	
O17-OT-15	2							3.1835
O17-OT-5	2							3.2542
Sig.		.055	.062	.066	.059	.173	.171	.674

Means for groups in homogeneous subsets are displayed.

TCC

Duncan

Sample	N	Subset for alpha = 0.05						
		1	2	3	4	5	6	7
O17-OT-8	2	6.8300						
O17-OT-9	2	7.4400	7.4400					
O17-OT-14	2		8.9150	8.9150				
O17-OT-13	2			9.2100	9.2100			
O17-OT-16	2			9.3100	9.3100	9.3100		
O17-OT-12	2			9.4000	9.4000	9.4000		
O17-OT-4	2			9.4150	9.4150	9.4150		
O17-OT-10	2			9.9200	9.9200	9.9200	9.9200	
O17-OT-3	2			10.1300	10.1300	10.1300	10.1300	
O17-OT-5	2			10.4450	10.4450	10.4450	10.4450	
O17-OT-17	2			10.5000	10.5000	10.5000	10.5000	
O17-OT-7	2				10.7000	10.7000	10.7000	10.7000
O17-OT-2	2				10.8450	10.8450	10.8450	10.8450
O17-OT-11	2					10.9800	10.9800	10.9800
O17-OT-6	2						11.1400	11.1400
O17-OT-1	2						11.4400	11.4400
O17-OT-15	2							12.3350
Sig.		.403	.054	.068	.062	.057	.079	.055

Means for groups in homogeneous subsets are displayed.

GC

Duncan

Sample	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
O17-OT-5	2	1.2064					
O17-OT-16	2	1.2253					
O17-OT-2	2	1.2727	1.2727				
O17-OT-13	2	1.3109	1.3109	1.3109			
O17-OT-15	2	1.3311	1.3311	1.3311			
O17-OT-4	2	1.3402	1.3402	1.3402	1.3402		
O17-OT-10	2	1.3417	1.3417	1.3417	1.3417		
O17-OT-12	2		1.4290	1.4290	1.4290	1.4290	
O17-OT-11	2		1.4404	1.4404	1.4404	1.4404	1.4404
O17-OT-3	2		1.4405	1.4405	1.4405	1.4405	1.4405
O17-OT-14	2		1.4464	1.4464	1.4464	1.4464	1.4464
O17-OT-7	2		1.4543	1.4543	1.4543	1.4543	1.4543
O17-OT-6	2		1.4663	1.4663	1.4663	1.4663	1.4663
O17-OT-1	2			1.4707	1.4707	1.4707	1.4707
O17-OT-9	2				1.5275	1.5275	1.5275
O17-OT-8	2					1.6072	1.6072
O17-OT-17	2						1.6246
Sig.		.155	.052	.102	.059	.069	.061

Means for groups in homogeneous subsets are displayed.

EGC

Duncan

Sample	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
O17-OT-8	2	1.3514					
O17-OT-9	2	1.5544					
O17-OT-5	2		2.2007				
O17-OT-16	2		2.2570				
O17-OT-14	2		2.3765				
O17-OT-13	2		2.5303	2.5303			
O17-OT-12	2		2.7234	2.7234	2.7234		
O17-OT-17	2			3.0947	3.0947	3.0947	
O17-OT-10	2			3.1014	3.1014	3.1014	
O17-OT-6	2			3.2033	3.2033	3.2033	
O17-OT-11	2			3.2145	3.2145	3.2145	
O17-OT-4	2				3.3001	3.3001	
O17-OT-7	2				3.3913	3.3913	3.3913
O17-OT-2	2					3.4461	3.4461
O17-OT-15	2					3.4560	3.4560
O17-OT-3	2					3.5752	3.5752
O17-OT-1	2						4.0596
Sig.		.500	.127	.053	.061	.171	.055

Means for groups in homogeneous subsets are displayed.

C

Duncan

Sample	N	Subset for alpha = 0.05						
		1	2	3	4	5	6	7
O17-OT-2	2	.5859						
O17-OT-7	2	.6452	.6452					
O17-OT-12	2	.6702	.6702					
O17-OT-6	2	.6741	.6741	.6741				
O17-OT-1	2	.6994	.6994	.6994				
O17-OT-4	2	.7328	.7328	.7328	.7328			
O17-OT-3	2	.7439	.7439	.7439	.7439			
O17-OT-13	2	.7796	.7796	.7796	.7796	.7796		
O17-OT-10	2		.7958	.7958	.7958	.7958	.7958	
O17-OT-14	2		.8042	.8042	.8042	.8042	.8042	
O17-OT-11	2			.8658	.8658	.8658	.8658	
O17-OT-16	2				.9056	.9056	.9056	
O17-OT-9	2				.9139	.9139	.9139	
O17-OT-8	2					.9465	.9465	.9465
O17-OT-15	2					.9567	.9567	.9567
O17-OT-17	2						.9891	.9891
O17-OT-5	2							1.1100
Sig.		.050	.104	.053	.066	.071	.051	.079

Means for groups in homogeneous subsets are displayed.

EC

Duncan

Sample	N	Subset for alpha = 0.05							
		1	2	3	4	5	6	7	8
O17-OT-12	2	.7512							
O17-OT-2	2	.8400	.8400						
O17-OT-7	2	.8494	.8494	.8494					
O17-OT-16	2	.8542	.8542	.8542					
O17-OT-13	2	.8919	.8919	.8919	.8919				
O17-OT-6	2		.9190	.9190	.9190				
O17-OT-9	2		.9242	.9242	.9242				
O17-OT-14	2		.9376	.9376	.9376				
O17-OT-10	2		.9510	.9510	.9510				
O17-OT-1	2			.9900	.9900				
O17-OT-4	2				1.0074	1.0074			
O17-OT-3	2				1.0185	1.0185	1.0185		
O17-OT-11	2				1.0320	1.0320	1.0320	1.0320	
O17-OT-17	2					1.1436	1.1436	1.1436	1.1436
O17-OT-8	2						1.1573	1.1573	1.1573
O17-OT-5	2							1.1642	1.1642
O17-OT-15	2								1.2214
Sig.		.053	.130	.060	.062	.056	.052	.063	.260

Means for groups in homogeneous subsets are displayed.

ECGC

Duncan

Sample	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
O17-OT-8	2	.8689					
O17-OT-9	2	1.3355					
O17-OT-14	2		2.1223				
O17-OT-4	2		2.1450				
O17-OT-13	2		2.3499	2.3499			
O17-OT-3	2		2.3834	2.3834			
O17-OT-17	2		2.4249	2.4249	2.4249		
O17-OT-10	2		2.5100	2.5100	2.5100	2.5100	
O17-OT-12	2		2.5969	2.5969	2.5969	2.5969	
O17-OT-16	2		2.6145	2.6145	2.6145	2.6145	
O17-OT-5	2		2.9547	2.9547	2.9547	2.9547	2.9547
O17-OT-7	2			3.0349	3.0349	3.0349	3.0349
O17-OT-11	2			3.0493	3.0493	3.0493	3.0493
O17-OT-1	2			3.0878	3.0878	3.0878	3.0878
O17-OT-6	2				3.2769	3.2769	3.2769
O17-OT-2	2					3.3256	3.3256
O17-OT-15	2						3.6171
Sig.		.207	.056	.088	.051	.061	.118

Means for groups in homogeneous subsets are displayed.

GCG

Duncan

Sample	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
O17-OT-4	2	.4648					
O17-OT-3	2	.5328	.5328				
O17-OT-1	2	.5631	.5631	.5631			
O17-OT-8	2	.6243	.6243	.6243	.6243		
O17-OT-17	2	.6661	.6661	.6661	.6661	.6661	
O17-OT-9	2	.7109	.7109	.7109	.7109	.7109	.7109
O17-OT-10	2	.7445	.7445	.7445	.7445	.7445	.7445
O17-OT-7	2	.7621	.7621	.7621	.7621	.7621	.7621
O17-OT-11	2	.7628	.7628	.7628	.7628	.7628	.7628
O17-OT-12	2	.7659	.7659	.7659	.7659	.7659	.7659
O17-OT-14	2		.7784	.7784	.7784	.7784	.7784
O17-OT-2	2		.8201	.8201	.8201	.8201	.8201
O17-OT-13	2			.8595	.8595	.8595	.8595
O17-OT-5	2				.8791	.8791	.8791
O17-OT-16	2				.9324	.9324	.9324
O17-OT-15	2					.9458	.9458
O17-OT-6	2						.9924
Sig.		.054	.066	.059	.051	.073	.072

Means for groups in homogeneous subsets are displayed.

ECG

Duncan

Sample	N	Subset for alpha = 0.05			
		1	2	3	4
O17-OT-8	2	.2673			
O17-OT-4	2	.4252	.4252		
O17-OT-3	2	.4365	.4365		
O17-OT-12	2	.4605	.4605		
O17-OT-14	2	.4664	.4664		
O17-OT-10	2	.4787	.4787		
O17-OT-9	2	.4805	.4805		
O17-OT-13	2	.4812	.4812		
O17-OT-16	2		.5190		
O17-OT-17	2		.5557		
O17-OT-2	2		.5562		
O17-OT-7	2		.5600		
O17-OT-1	2		.5667		
O17-OT-6	2		.6014	.6014	
O17-OT-11	2		.6147	.6147	
O17-OT-15	2			.8173	.8173
O17-OT-5	2				.9319
Sig.		.079	.120	.056	.270

Means for groups in homogeneous subsets are displayed.

DPPH

Duncan

Sample	N	Subset for alpha = 0.05							
		1	2	3	4	5	6	7	8
O17-OT-4	2	1.0536E2							
O17-OT-5	2	1.1784E2	1.1784E2						
O17-OT-6	2		1.2162E2	1.2162E2					
O17-OT-3	2		1.2332E2	1.2332E2					
O17-OT-7	2		1.2338E2	1.2338E2					
O17-OT-2	2		1.2412E2	1.2412E2					
O17-OT-14	2		1.3114E2	1.3114E2	1.3114E2				
O17-OT-1	2		1.3180E2	1.3180E2	1.3180E2				
O17-OT-16	2			1.3418E2	1.3418E2	1.3418E2			
O17-OT-10	2				1.4114E2	1.4114E2			
O17-OT-12	2				1.4262E2	1.4262E2	1.4262E2		
O17-OT-13	2				1.4481E2	1.4481E2	1.4481E2	1.4481E2	
O17-OT-8	2					1.4772E2	1.4772E2	1.4772E2	
O17-OT-9	2						1.5676E2	1.5676E2	1.5676E2
O17-OT-17	2							1.5961E2	1.5961E2
O17-OT-11	2								1.6302E2
O17-OT-15	2								1.6461E2
Sig.		.072	.075	.107	.078	.077	.061	.051	.284

Means for groups in homogeneous subsets are displayed.

FRAP

Duncan

Sample	N	Subset for alpha = 0.05				
		1	2	3	4	5
O17-OT-14	2	1.5000				
O17-OT-4	2	1.5450	1.5450			
O17-OT-10	2	1.5450	1.5450			
O17-OT-7	2	1.5650	1.5650	1.5650		
O17-OT-16	2	1.5750	1.5750	1.5750		
O17-OT-12	2	1.6250	1.6250	1.6250	1.6250	
O17-OT-9	2	1.6300	1.6300	1.6300	1.6300	
O17-OT-3	2	1.6500	1.6500	1.6500	1.6500	
O17-OT-6	2	1.6550	1.6550	1.6550	1.6550	
O17-OT-2	2	1.6800	1.6800	1.6800	1.6800	
O17-OT-8	2	1.6900	1.6900	1.6900	1.6900	
O17-OT-13	2		1.7150	1.7150	1.7150	1.7150
O17-OT-11	2		1.7200	1.7200	1.7200	1.7200
O17-OT-1	2			1.7450	1.7450	1.7450
O17-OT-5	2			1.7500	1.7500	1.7500
O17-OT-17	2				1.7850	1.7850
O17-OT-15	2					1.9000
Sig.		.057	.077	.063	.102	.055

Means for groups in homogeneous subsets are displayed.

Appendix 27. Comparison of chemical content

Comparison of chemical content between *Camellia sinensis* var. *assamica* andvar. *sinensis*

Variety	**MC (%w/**	**TPC (%GAE**	**Antioxidant**		**CF (%w/w)***
			DPPH-assay (mmolTE/100g)	**FRAP-assay (mmolAA/100g)***	
Assamic	6.09 ± 1.	18.95 ± 1.46	183.90 ± 46.68	2.01 ± 0.37	3.44 ± 0.51
Sinensi	5.39 ± 0.	14.58 ± 1.81	146.97 ± 56.40	1.12 ± 0.16	2.50 ± 0.70

Results are mean ± SD (var. *assamica* = 6; var. *sinensis* = 7). For each column, assay label which is followed by the star statistically different at P < 0.05 as measured by the T-test.

Comparison of single catechins content between *Camellia sinensis* var. *assamica* andvar. *sinensis*

Variety	**TCC (%w/w)**	**Cathecins (%w/w)**							
		GC	**EGC***	**C***	**EC***	**EGCG***	**GCG**	**ECG***	**CG**
Assamica	12.43 ± 2.42	0.84 ± 0.28	1.77 ± 0.60	1.65 ± 0.38	2.23 ± 0.60	2.62 ± 0.94	0.45 ± 0.27	2.94 ± 0.79	n.d
Oolong	10.86 ± 1.58	0.94 ± 0.14	2.75 ± 0.48	0.84 ± 0.17	0.92 ± 0.14	3.99 ± 0.92	0.65 ± 0.44	0.78 ± 0.28	n.d

Results are mean ± SD (var. *assamica* = 6; var. *sinensis* = 7). For each column, assay label which is followed by the star statistically different at P < 0.05 as measured by the T-test.

Comparison of chemical content between *Camellia sinensis* var. *sinensis* (cv. oolong no. 12)and *Camellia sinensis* var. *sinensis* (cv. oolong no. 17)

Oolong no	**MC (%w/w)***	**TPC (%GAE)**	**Antioxidant**		**CF (%w/w)**
			DPPH-assay (mmolTE/100g)*	**FRAP-assay (mmolAA/100g)**	
Oolong 12	4.57 ± 2.26	14.08 ± 2.70	124.21 ± 20.06	1.68 ± 0.26	2.55 ± 0.61
Oolong 17	3.02 ± 1.87	14.90 ± 1.21	137.24 ± 17.65	1.66 ± 0.12	2.25 ± 0.48

Results are mean ± SD (oolong no. 12 = 9; oolong no. 17 = 17). For each column, assay label which is followed by the star is statistically different at P < 0.05 as measured by the T-test.

Comparison of catechin content between *Camellia sinensis* var. *sinensis* (cv. oolong no. 12)and *Camellia sinensis* var. *sinensis* (cv. oolong no. 17)

Oolong no	**TCC (%w/w)**	**Cathecins (%w/w)**							
		GC*	**EGC**	**C**	**EC**	**EGCG***	**GCG**	**ECG***	**CG**
Oolong 12	10.58 ± 2.17	0.98 ± 0.16	2.78 ± 0.57	0.81 ± 0.29	0.96 ± 0.23	3.58 ± 0.98	0.71 ± 0.34	0.77 ± 0.45	n.d
Oolong 17	9.94 ± 1.46	1.41 ± 0.13	2.87 ± 0.75	0.81 ± 0.15	0.99 ± 0.13	2.57 ± 0.74	0.75 ± 0.17	0.54 ± 0.17	n.d

Results are mean ± SD (oolong no. 12 = 9; oolong no. 17 = 17). For each column, assay label which is followed by the star is statistically different at P < 0.05 as measured by the T-test.

Cont'd appendix 27

Comparison of chemical content between green tea and oolong tea

Tea type	MC (%w/w)*	TPC (%GAE)*	Antioxidant		CF (%w/w)*
			DPPH-assay (mmolTE/100g)*	FRAP-assay (mmolAA/100g)	
green tea	5.71 ± 1.22	16.93 ± 2.75	164.01 ± 54.45	1.53 ± 0.53	2.93 ± 0.77
oolong tea	3.56 ± 2.12	14.62 ± 1.87	132.73 ± 19.36	1.67 ± 0.18	2.34 ± 0.54

Results are mean ± SD (green tea = 13; oolong tea = 26). For each column, assay label which is followed by the star is statistically different at $P < 0.05$ as measured by the T-test.

Comparison of catechin content between green tea and oolong tea

Tea type	TCC (%w/w) *	Cathecins (%w/w)							
		GC*	EGC*	C*	EC*	EGCG	GCG*	ECG*	CG
green tea	11.58 ± 2.12	0.89 ± 0.22	2.29 ± 0.73	1.21 ± 0.50	1.53 ± 0.78	3.36 ± 1.15	0.53 ± 0.28	1.77 ± 1.23	n.d
oolong tea	10.16 ± 1.74	1.26 ± 0.25	2.84 ± 0.69	0.81 ± 0.21	0.97 ± 0.17	2.92 ± 0.96	0.74 ± 0.24	0.62 ± 0.31	n.d.

Results are mean ± SD (green tea = 13; oolong tea = 26). For each column, values followed by the same letter are not statistically different at $P < 0.05$ as measured by the T-test.

Appendix 28. T-test results of Green tea var. *sinensis(*oolong) and var. *assamica*

Group Statistics

	sample	N	Mean	Std. Deviation	Std. Error Mean
Moist	Gr.oolong	14	5.3849	.78214	.20904
	Gr.Assam	12	6.0907	1.54016	.44461
tpc	Gr.oolong	14	14.9057	1.80741	.48305
	Gr.Assam	12	19.3008	1.44654	.41758
dpph	Gr.oolong	14	1.4697E2	56.39996	15.07352
	Gr.Assam	12	1.8390E2	46.68058	13.47552
frap	Gr.oolong	14	1.1157	.15883	.04245
	Gr.Assam	12	2.0100	.36467	.10527
CAFFEINE	Gr.oolong	14	2.4959	.69555	.18589
	Gr.Assam	12	3.4417	.50757	.14652
TCC	Gr.oolong	14	10.8580	1.58057	.42242
	Gr.Assam	12	12.4265	2.41596	.69743
GC	Gr.oolong	14	.9376	.14368	.03840
	Gr.Assam	12	.8369	.28162	.08130
EGC	Gr.oolong	14	2.7487	.47967	.12820
	Gr.Assam	12	1.7655	.60087	.17346
C	Gr.oolong	14	.8345	.16971	.04536
	Gr.Assam	12	1.6531	.38253	.11043
EC	Gr.oolong	14	.9224	.14291	.03819
	Gr.Assam	12	2.2278	.60498	.17464
ECGC	Gr.oolong	14	3.9899	.91576	.24475
	Gr.Assam	12	2.6171	.93774	.27070
GCG	Gr.oolong	14	.6472	.22746	.06079
	Gr.Assam	10	.4451	.26754	.08461
ECG	Gr.oolong	14	.7749	.28084	.07506
	Gr.Assam	12	2.9383	.78510	.22664

Cont'd appendix 28. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Moist	Equal variances assumed	1.485	.235	-1.506	24	.145	-.70578	.46855	-1.67282	.26126
	Equal variances not assumed			-1.437	15.749	.170	-.70578	.49130	-1.74863	.33707
tpc	Equal variances assumed	.444	.512	-6.764	24	.000	-4.39512	.64983	-5.73629	-3.05395
	Equal variances not assumed			-6.883	23.910	.000	-4.39512	.63852	-5.71323	-3.07701
dpph	Equal variances assumed	.328	.572	-1.799	24	.085	-36.92988	20.52376	-79.28885	5.42909
	Equal variances not assumed			-1.827	23.981	.080	-36.92988	20.21882	-78.66126	4.80149
frap	Equal variances assumed	10.836	.003	-8.322	24	.000	-.89429	.10746	-1.11607	-.67250
	Equal variances not assumed			-7.879	14.543	.000	-.89429	.11351	-1.13688	-.65169
CAFFEINE	Equal variances assumed	4.273	.050	-3.899	24	.001	-.94577	.24255	-1.44637	-.44517
	Equal variances not assumed			-3.996	23.466	.001	-.94577	.23670	-1.43488	-.45666
TCC	Equal variances assumed	2.061	.164	-1.986	24	.059	-1.56850	.78959	-3.19813	.06112
	Equal variances not assumed			-1.924	18.450	.070	-1.56850	.81538	-3.27857	.14156
GC	Equal variances assumed	3.430	.076	1.174	24	.252	.10072	.08577	-.07630	.27773
	Equal variances not assumed			1.120	15.790	.279	.10072	.08991	-.09009	.29152
EGC	Equal variances assumed	.596	.448	4.640	24	.000	.98323	.21189	.54591	1.42055
	Equal variances not assumed			4.559	20.998	.000	.98323	.21569	.53468	1.43179
C	Equal variances assumed	1.772	.196	-7.237	24	.000	-.81863	.11311	-1.05208	-.58518
	Equal variances not assumed			-6.857	14.671	.000	-.81863	.11938	-1.07358	-.56368
EC	Equal variances assumed	7.701	.011	-7.848	24	.000	-1.30546	.16635	-1.64880	-.96212
	Equal variances not assumed			-7.302	12.054	.000	-1.30546	.17877	-1.69478	-.91615

Cont’d appendix 28

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
ECGC	Equal variances assumed	.002	.968	3.769	24	.001	1.37278	.36425	.62101	2.12455
	Equal variances not assumed			3.762	23.211	.001	1.37278	.36494	.61823	2.12734
GCG	Equal variances assumed	.022	.883	1.996	22	.058	.20216	.10130	-.00792	.41224
	Equal variances not assumed			1.940	17.469	.069	.20216	.10418	-.01719	.42151
ECG	Equal variances assumed	.022	.883	1.996	22	.058	.20216	.22435	-2.62643	-1.70035
	Equal variances not assumed			1.940	17.469	.069	.20216	.23874	-2.67757	-1.64921

Appendix 29. T-test results of oolong tea no. 12 and no. 17

Group Statistics

	Sample	N	Mean	Std. Deviation	Std. Error Mean
Moist	Oolong 17	34	3.0177	1.86523	.31989
	Oolong 12	18	4.5719	2.25565	.53166
tpc	Oolong 17	34	14.8988	1.20458	.20658
	Oolong 12	18	14.0817	2.69490	.63519
dpph	Oolong 17	34	1.3724E2	17.64773	3.02656
	Oolong 12	18	1.2421E2	20.05888	4.72792
frap	Oolong 17	34	1.6632	.11599	.01989
	Oolong 12	18	1.6756	.26462	.06237
TCC	Oolong 17	34	9.9385	1.46230	.25078
	Oolong 12	18	10.5794	2.16518	.51034
GC	Oolong 17	34	1.4079	.13165	.02258
	Oolong 12	18	.9781	.16164	.03810
EGC	Oolong 17	34	2.8727	.75306	.12915
	Oolong 12	18	2.7785	.56669	.13357
C	Oolong 17	34	.8129	.15173	.02602
	Oolong 12	18	.8088	.29111	.06862
EC	Oolong 17	34	.9796	.13697	.02349
	Oolong 12	18	.9581	.23254	.05481
ECGC	Oolong 17	34	2.5704	.73909	.12675
	Oolong 12	18	3.5831	.98249	.23158
GCG	Oolong 17	34	.7532	.17229	.02955
	Oolong 12	18	.7065	.33752	.07955
ECG	Oolong 17	34	.5423	.16485	.02827
	Oolong 12	18	.7671	.44677	.10530
CF	Oolong 17	34	2.2493	.47953	.08224
	Oolong 12	16	2.5456	.60822	.15206

Cont'd appendix 29. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Moist	Equal variances assumed	.509	.479	-2.657	50	.011	-1.55416	.58488	-2.72893	-.37939
	Equal variances not assumed			-2.505	29.542	.018	-1.55416	.62048	-2.82216	-.28615
tpc	Equal variances assumed	28.077	.000	1.514	50	.136	.81716	.53961	-.26668	1.90099
	Equal variances not assumed			1.223	20.667	.235	.81716	.66794	-.57327	2.20758
dpph	Equal variances assumed	1.231	.273	2.415	50	.019	13.02405	5.39341	2.19106	23.85704
	Equal variances not assumed			2.320	31.097	.027	13.02405	5.61367	1.57634	24.47176
frap	Equal variances assumed	24.892	.000	-.234	50	.816	-.01232	.05270	-.11817	.09353
	Equal variances not assumed			-.188	20.524	.853	-.01232	.06547	-.14866	.12402
TCC	Equal variances assumed	3.000	.089	-1.268	50	.211	-.64092	.50532	-1.65587	.37404
	Equal variances not assumed			-1.127	25.437	.270	-.64092	.56863	-1.81100	.52917
GC	Equal variances assumed	.520	.474	10.344	50	.000	.42986	.04155	.34639	.51332
	Equal variances not assumed			9.706	29.184	.000	.42986	.04429	.33930	.52041
EGC	Equal variances assumed	3.062	.086	.465	50	.644	.09419	.20268	-.31290	.50129
	Equal variances not assumed			.507	43.885	.615	.09419	.18580	-.28028	.46867
C	Equal variances assumed	.755	.389	.067	50	.947	.00409	.06115	-.11873	.12691
	Equal variances not assumed			.056	22.007	.956	.00409	.07338	-.14809	.15628
EC	Equal variances assumed	.791	.378	.421	50	.676	.02151	.05113	-.08119	.12421
	Equal variances not assumed			.361	23.411	.722	.02151	.05963	-.10173	.14475
ECGC	Equal variances assumed	3.710	.060	-4.186	50	.000	-1.01270	.24191	-1.49859	-.52681
	Equal variances not assumed			-3.836	27.443	.001	-1.01270	.26400	-1.55397	-.47143

Cont'd appendix 29

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
GCG	Equal variances assumed	14.187	.000	.664	50	.510	.04676	.07040	-.09464	.18815
	Equal variances not assumed			.551	21.800	.587	.04676	.08486	-.12933	.22284
ECG	Equal variances assumed	7.098	.010	-2.633	50	.011	-.22477	.08538	-.39627	-.05327
	Equal variances not assumed			-2.061	19.487	.053	-.22477	.10903	-.45260	.00305
CF	Equal variances assumed	.292	.592	-1.869	48	.068	-.29637	.15861	-.61526	.02253
	Equal variances not assumed			-1.714	24.121	.099	-.29637	.17287	-.65306	.06033

Appendix 30. T-test results of green tea and oolong tea

Group Statistics

	sample	N	Mean	Std. Deviation	Std. Error Mean
Moist	Green	26	5.7107	1.22089	.23944
	Oolong	52	3.5557	2.12240	.29432
tpc	Green	26	16.9342	2.75901	.54109
	Oolong	52	14.6160	1.87452	.25995
dpph	Green	26	1.6401E2	54.45534	10.67957
	Oolong	52	1.3273E2	19.35938	2.68466
frap	Green	26	1.5285	.52757	.10347
	Oolong	52	1.6675	.17911	.02484
TCC	Green	26	11.5820	2.12206	.41617
	Oolong	52	10.1604	1.74387	.24183
GC	Green	26	.8911	.21967	.04308
	Oolong	52	1.2592	.25013	.03469
EGC	Green	26	2.2949	.72689	.14256
	Oolong	52	2.8401	.68995	.09568
C	Green	26	1.2123	.50257	.09856
	Oolong	52	.8114	.20772	.02881
EC	Green	26	1.5249	.78239	.15344
	Oolong	52	.9722	.17399	.02413
ECGC	Green	26	3.3563	1.14459	.22447
	Oolong	52	2.9210	.95493	.13243
ECG	Green	26	1.7734	1.23365	.24194
	Oolong	52	.6201	.30948	.04292
CF	Green	26	2.9324	.77209	.15142
	Oolong	50	2.3441	.53629	.07584
GCG2	Green	24	.5630	.26004	.05308
	Oolong	52	.7370	.24017	.03331

Cont’d appendix 30. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Moist	Equal variances assumed	34.080	.000	4.787	76	.000	2.15494	.45020	1.25829	3.05160
	Equal variances not assumed			5.680	74.382	.000	2.15494	.37942	1.39901	2.91088
tpc	Equal variances assumed	8.006	.006	4.377	76	.000	2.31827	.52962	1.26344	3.37310
	Equal variances not assumed			3.862	36.908	.000	2.31827	.60029	1.10187	3.53467
dpph	Equal variances assumed	49.476	.000	3.718	76	.000	31.28423	8.41344	14.52742	48.04104
	Equal variances not assumed			2.841	28.204	.008	31.28423	11.01184	8.73485	53.83361
frap	Equal variances assumed	55.886	.000	-1.721	76	.089	-.13904	.08077	-.29991	.02183
	Equal variances not assumed			-1.307	27.919	.202	-.13904	.10641	-.35703	.07895
TCC	Equal variances assumed	2.549	.115	3.154	76	.002	1.42158	.45077	.52379	2.31937
	Equal variances not assumed			2.953	42.366	.005	1.42158	.48133	.45046	2.39270
GC	Equal variances assumed	2.358	.129	-6.371	76	.000	-.36806	.05777	-.48313	-.25299
	Equal variances not assumed			-6.655	56.319	.000	-.36806	.05531	-.47885	-.25728
EGC	Equal variances assumed	.052	.821	-3.232	76	.002	-.54521	.16869	-.88119	-.20923
	Equal variances not assumed			-3.176	47.838	.003	-.54521	.17169	-.89044	-.19998
C	Equal variances assumed	50.655	.000	4.986	76	.000	.40089	.08040	.24077	.56102
	Equal variances not assumed			3.904	29.348	.001	.40089	.10268	.19099	.61080
EC	Equal variances assumed	166.365	.000	4.888	76	.000	.55275	.11309	.32751	.77798
	Equal variances not assumed			3.559	26.244	.001	.55275	.15533	.23362	.87188
ECGC	Equal variances assumed	1.365	.246	1.775	76	.080	.43526	.24529	-.05327	.92380
	Equal variances not assumed			1.670	42.883	.102	.43526	.26062	-.09037	.96090

Cont'd appendix 30

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
ECG	Equal variances assumed	206.218	.000	6.389	76	.000	1.15332	.18053	.79377	1.51287
	Equal variances not assumed			4.694	26.585	.000	1.15332	.24572	.64879	1.65786
CF	Equal variances assumed	8.158	.006	3.887	74	.000	.58830	.15135	.28672	.88987
	Equal variances not assumed			3.474	37.901	.001	.58830	.16935	.24544	.93116
GCG2	Equal variances assumed	.093	.761	-2.861	74	.005	-.17404	.06083	-.29526	-.05283
	Equal variances not assumed			-2.777	41.757	.008	-.17404	.06266	-.30052	-.04756

Appendix 31 Correlation analysis by Minitab

All samples

	MC	TPC	CF	TCC	GC	EGC	C	EC	EGCG
TPC	0.300								
	0.063								
CF	0.197	0.434							
	0.230	0.006							
TCC	0.219	0.685	0.405						
	0.180	0.000	0.010						
GC	-0.449	-0.220	-0.363	-0.329					
	0.004	0.178	0.023	0.041					
EGC	-0.272	-0.219	-0.420	0.172	0.374				
	0.094	0.181	0.008	0.295	0.019				
C	0.277	0.689	0.705	0.518	-0.405	-0.636			
	0.088	0.000	0.000	0.001	0.010	0.000			
EC	0.259	0.680	0.615	0.568	-0.380	-0.495	0.918		
	0.111	0.000	0.000	0.000	0.017	0.001	0.000		
EGCG	0.155	0.190	-0.005	0.637	-0.333	0.428	-0.145	-0.187	
	0.345	0.247	0.976	0.000	0.038	0.007	0.378	0.253	
GCG	-0.176	-0.111	-0.229	0.055	0.439	0.223	-0.385	-0.484	0.418
	0.283	0.500	0.161	0.739	0.005	0.172	0.016	0.002	0.008
ECG	0.371	0.668	0.621	0.589	-0.584	-0.555	0.912	0.947	-0.071
	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.668
DPPH	0.106	0.649	0.381	0.451	-0.206	-0.206	0.467	0.541	0.105
	0.522	0.000	0.017	0.004	0.209	0.208	0.003	0.000	0.524
FRAP	0.103	0.648	0.209	0.358	0.060	-0.119	0.474	0.420	-0.083
	0.533	0.000	0.201	0.025	0.718	0.472	0.002	0.008	0.617

	GCG	ECG	DPPH
ECG	-0.492		
	0.001		
DPPH	-0.161	0.497	
	0.329	0.001	
FRAP	0.000	0.395	0.181
	0.998	0.013	0.270

Cell Contents: Pearson correlation
P-Value

Correlation A-GT

	TPC	CF	TCC	GC	EGC	C	EC	EGCG	GCG
CF	0.060								
	0.911								
TCC	0.558	-0.075							
	0.250	0.888							
GC	0.676	-0.349	0.821						
	0.141	0.498	0.045						
EGC	0.590	-0.481	0.819	0.927					
	0.218	0.334	0.046	0.008					
C	0.187	0.227	0.409	0.040	-0.075				
	0.723	0.665	0.420	0.940	0.887				
EC	-0.057	0.553	0.552	0.037	0.009	0.644			
	0.915	0.255	0.257	0.944	0.986	0.168			
EGCG	0.679	-0.552	0.658	0.895	0.958	-0.197	-0.251		
	0.138	0.257	0.155	0.016	0.003	0.708	0.631		
GCG	0.791	-0.167	0.431	0.794	0.721	-0.363	-0.351	0.831	
	0.061	0.751	0.393	0.059	0.106	0.479	0.495	0.041	
ECG	-0.449	0.592	0.052	-0.457	-0.495	0.624	0.846	-0.710	-0.762
	0.372	0.216	0.923	0.362	0.318	0.186	0.034	0.114	0.078
DPPH	0.283	0.585	0.359	0.383	0.224	-0.200	0.365	0.136	0.485
	0.587	0.222	0.485	0.453	0.669	0.704	0.477	0.797	0.329
FRAP	0.532	-0.503	0.038	0.177	0.264	0.172	-0.495	0.443	0.261
	0.277	0.309	0.943	0.737	0.613	0.745	0.318	0.378	0.617

	ECG	DPPH
DPPH	0.071	
	0.893	
FRAP	-0.533	-0.647
	0.276	0.165

Cell Contents: Pearson correlation
P-Value

Correlation O12-GT

	TPC	CF	TCC	GC	EGC	C	EC	EGCG	GCG
CF	0.817								
	0.025								
TCC	0.981	0.726							
	0.000	0.065							
GC	-0.405	-0.444	-0.299						
	0.367	0.318	0.515						
EGC	-0.033	-0.428	0.034	0.144					
	0.944	0.338	0.942	0.759					
C	0.903	0.957	0.862	-0.375	-0.294				
	0.005	0.001	0.013	0.407	0.522				
EC	0.941	0.843	0.928	-0.488	-0.078	0.940			
	0.002	0.017	0.003	0.267	0.868	0.002			
EGCG	0.980	0.775	0.974	-0.448	-0.124	0.874	0.927		
	0.000	0.041	0.000	0.314	0.791	0.010	0.003		
GCG	0.466	0.434	0.525	0.323	-0.545	0.513	0.382	0.529	
	0.291	0.331	0.226	0.479	0.206	0.239	0.398	0.222	
ECG	0.940	0.850	0.894	-0.652	-0.217	0.895	0.944	0.958	0.377
	0.002	0.016	0.007	0.113	0.640	0.006	0.001	0.001	0.405
DPPH	0.504	0.432	0.462	-0.824	0.124	0.471	0.679	0.511	-0.289
	0.249	0.333	0.297	0.023	0.791	0.286	0.094	0.241	0.530
FRAP	0.985	0.805	0.948	-0.437	-0.057	0.857	0.899	0.964	0.444
	0.000	0.029	0.001	0.327	0.904	0.014	0.006	0.000	0.318

	ECG	DPPH
DPPH	0.672	
	0.098	
FRAP	0.934	0.500
	0.002	0.253

Cell Contents: Pearson correlation
P-Value

Correlation O12-OT

	TPC	CF	TCC	GC	EGC	C	EC	EGCG	GCG
CF	-0.427								
	0.252								
TCC	0.743	-0.221							
	0.022	0.568							
GC	0.119	0.461	0.275						
	0.761	0.212	0.474						
EGC	0.593	-0.133	0.254	-0.067					
	0.093	0.733	0.509	0.865					
C	-0.164	0.478	0.328	0.426	-0.599				
	0.673	0.193	0.389	0.253	0.088				
EC	0.057	0.477	0.512	0.143	-0.200	0.807			
	0.883	0.194	0.159	0.714	0.605	0.009			
EGCG	0.828	-0.509	0.945	0.132	0.270	0.113	0.260		
	0.006	0.161	0.000	0.736	0.482	0.771	0.499		
GCG	0.370	-0.282	0.633	0.406	-0.376	0.371	0.161	0.683	
	0.328	0.462	0.067	0.278	0.319	0.326	0.679	0.043	
ECG	0.116	0.074	0.718	0.097	-0.254	0.689	0.821	0.557	0.474
	0.767	0.850	0.029	0.804	0.510	0.040	0.007	0.119	0.198
DPPH	0.972	-0.367	0.755	0.151	0.535	-0.082	0.167	0.814	0.360
	0.000	0.332	0.019	0.697	0.138	0.834	0.668	0.008	0.341
FRAP	0.975	-0.371	0.738	0.290	0.555	-0.112	0.006	0.813	0.444
	0.000	0.325	0.023	0.449	0.121	0.774	0.989	0.008	0.231

	ECG	DPPH
DPPH	0.197	
	0.612	
FRAP	0.076	0.926
	0.846	0.000

Cell Contents: Pearson correlation
P-Value

Correlation O17-OT

	TPC	CF	TCC	GC	EGC	C	EC	EGCG	GCG
CF	0.620								
	0.008								
TCC	0.398	0.375							
	0.114	0.138							
GC	0.133	-0.351	-0.295						
	0.611	0.168	0.250						
EGC	0.071	-0.136	0.842	-0.121					
	0.788	0.602	0.000	0.643					
C	0.564	0.638	-0.191	0.013	-0.538				
	0.018	0.006	0.464	0.961	0.026				
EC	0.715	0.482	0.146	0.186	-0.056	0.733			
	0.001	0.050	0.575	0.475	0.832	0.001			
EGCG	0.269	0.409	0.952	-0.478	0.745	-0.269	-0.069		
	0.297	0.103	0.000	0.052	0.001	0.296	0.793		
GCG	0.202	0.701	0.289	-0.438	-0.162	0.149	-0.138	0.479	
	0.438	0.002	0.260	0.078	0.535	0.567	0.596	0.052	
ECG	0.593	0.775	0.689	-0.479	0.248	0.384	0.366	0.711	0.543
	0.012	0.000	0.002	0.052	0.337	0.128	0.149	0.001	0.024
DPPH	0.630	0.298	-0.054	0.392	-0.228	0.435	0.290	-0.127	0.187
	0.007	0.246	0.836	0.120	0.380	0.081	0.258	0.627	0.472
FRAP	0.884	0.609	0.461	0.071	0.180	0.420	0.636	0.348	0.205
	0.000	0.009	0.062	0.788	0.490	0.093	0.006	0.171	0.429

	ECG	DPPH
DPPH	0.028	
	0.916	
FRAP	0.549	0.508
	0.022	0.037

Cell Contents: Pearson correlation
P-Value

Appendix 32 Principal Component Analysis

Sample A-GT, N=6

code	z1	z2	z3	z4	z5	z6	z7	z8	z9	z10	z11	z12	z13
1	-1.91157	0.508828	1.802028	0.362977	-0.28272	-0.27478	0.176417	1.163474	-0.45426	0.095344	0.863971	1.295612684	-0.6579
2	-0.50099	-0.46741	-0.08965	0.246737	0.723872	0.303691	-0.53411	0.11212	0.133584	0.431853	-0.05232	1.16145522	-1.34089
3	-2.1906	0.520168	0.018175	0.602886	0.23958	-0.11011	1.897276	0.699353	-0.19219	-0.47562	0.745838	-0.680769665	0.756831
4	-0.16974	1.287862	-0.64372	-0.2504	0.680964	0.647469	-0.91656	-1.62634	1.168869	1.539246	-1.8653	-0.101972771	1.40601
5	-0.09635	-0.26018	-1.15143	0.918594	0.533205	1.17299	-0.15373	0.294163	0.928469	-0.10855	-0.13575	-0.61707085	0.238958
6	4.86926	-1.58926	0.064593	-1.88079	-1.8949	-1.73926	-0.4693	-0.64277	-1.58448	-1.48227	0.443569	-1.057254618	-0.40301

Eigenanalysis of the Correlation Matrix

Eigenvalue	5.9713	3.7693	1.9448	1.1260	0.1885	0.0000	0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000	-0.0000
Proportion	0.459	0.290	0.150	0.087	0.015	0.000	0.000	0.000	0.000	-0.000	-0.000	-0.000	-0.000
Cumulative	0.459	0.749	0.899	0.985	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Variable	PC1	PC2
Moist	-0.292	-0.345
TPC	0.333	0.070
CF	-0.146	0.348
TCC	0.302	0.297
GC	0.388	0.081
EGC	0.381	0.018
C	-0.022	0.319
EC	-0.051	0.490
EGCG	0.394	-0.098
GCG	0.363	-0.073
ECG	-0.253	0.384
DPPH	0.120	0.292
FRAP	0.160	-0.264

Code	w1	w2
A-GT-1	-0.03829	2.934945
A-GT-2	0.573895	0.692406
A-GT-3	0.594616	1.971162
A-GT-4	2.854367	-2.4857
A-GT-5	1.351791	-0.307
A-GT-6	-5.33638	-2.80581

Sample O12-GT, N=7

code	z1	z2	z3	z4	z5	z6	z7	z8	z9	z10	z11	z12	z13
1	0.962952	-0.13963	0.057451	0.09012	1.372359	0.309879	0.373433	0.211969	-0.29107	0.528611	-0.49193	-0.470782249	-0.44422
2	0.156477	0.272641	0.441702	0.050459	-0.17168	0.508005	0.210484	-0.11514	0.023506	-0.62121	0.033644	-0.524777037	0.267822
3	0.151494	1.480815	0.953823	1.600289	-0.19775	-0.85743	1.210744	1.183971	1.728514	1.870541	1.420121	0.006315016	1.445396
4	-0.72569	-0.46408	-1.1383	-0.36973	0.990387	1.102389	-1.11766	-0.83259	-0.57075	-0.23401	-0.86316	-0.599454279	-0.22037
5	1.489359	-1.63372	-0.80246	-1.71196	0.390382	-1.47271	-1.16445	-1.56084	-1.42949	0.041608	-1.24458	-1.140198993	-1.56212
6	-1.34186	-0.35458	-0.94632	-0.21872	-0.99977	1.054223	-0.65807	-0.07281	-0.18441	-1.30379	-0.05535	1.119404712	-0.4578
7	-0.69273	0.838569	1.434099	0.559534	-1.38393	-0.64436	1.145512	1.185449	0.723707	-0.28175	1.201263	1.60949283	0.971288

Eigenanalysis of the Correlation Matrix

Eigenvalue	8.2674	2.7659	1.2721	0.3970	0.2204	0.0772	0.0000	0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000
Proportion	0.636	0.213	0.098	0.031	0.017	0.006	0.000	0.000	0.000	0.000	-0.000	-0.000	-0.000
Cumulative	0.636	0.849	0.947	0.977	0.994	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Variable	PC1	PC2
MC	-0.122	0.530
TPC	0.339	0.025
CF	0.302	0.159
TCC	0.327	0.038
GC	-0.191	0.329
EGC	-0.054	-0.402
C	0.324	0.146
EC	0.339	-0.018
EGCG	0.338	0.042
GCG	0.146	0.497
ECG	0.344	-0.024
DPPH	0.221	-0.389
FRAP	0.334	0.009

Sample	w1	w2
O12-GT-1	-0.64758	1.338824
O12-GT-2	0.160754	-0.16868
O12-GT-3	3.998273	1.747896
O12-GT-4	-2.15433	-0.75311
O12-GT-5	-4.11953	1.54769
O12-GT-6	-0.59076	-2.81824
O12-GT-7	3.353171	-0.89438

Sample O12-OT, N=9

code	z1	z2	z3	z4	z5	z6	z7	z8	z9	z10	z11	z12	z13
1	0.493474972	-0.87557	-0.20807	-1.01723	-0.38898	0.605905	-1.74164	-1.64944	-0.69018	-0.61563	-1.06369	-1.150767115	-0.78756
2	-0.728794542	-0.55178	0.16774	-0.77535	1.050906	-1.10956	0.794417	-0.11625	-0.70302	0.437284	-0.64217	-0.520377535	-0.07321
3	-1.367684788	-1.0005	-0.27757	-1.65173	-1.24701	-0.53989	-0.30919	-0.89685	-1.19341	-1.48782	-1.05813	-1.062264383	-1.1657
4	0.090775369	-1.46825	0.283072	0.418259	0.23122	-1.48417	1.899449	1.484893	-0.03377	0.568709	2.056555	-1.256831143	-1.72606
5	-1.458095466	0.201906	0.120469	-0.19217	-0.98978	1.330139	-0.63478	1.374076	-1.02541	-1.30208	-0.43747	0.34305851	-0.13963
6	0.305276328	0.534271	-0.08565	0.26801	1.260381	-0.05129	-0.09052	-0.29869	0.354104	0.470884	0.056602	0.791778493	0.989751
7	0.349127006	1.173674	-0.99896	1.247785	-1.20694	-0.22622	-0.32775	-0.28378	1.782088	1.456805	0.82833	1.163548171	0.844794
8	0.755674525	1.211984	-0.02518	1.267175	1.018294	1.443417	0.326389	0.442283	0.991361	-0.37316	0.440329	1.13513226	1.350167
9	1.560246596	0.774278	0.033504	0.435257	0.27191	0.031663	0.083625	-0.05625	0.518234	0.845015	-0.18036	0.556722742	0.707453

Eigenanalysis of the Correlation Matrix

Eigenvalue	5.7745	3.4282	1.4728	1.4215	0.5753	0.1911	0.1106	0.0260	0.0000	0.0000	0.0000	0.0000	-0.0000
Proportion	0.444	0.264	0.113	0.109	0.044	0.015	0.009	0.002	0.000	0.000	0.000	0.000	-0.000
Cumulative	0.444	0.708	0.821	0.931	0.975	0.989	0.998	1.000	1.000	1.000	1.000	1.000	1.000

Variable	PC1	PC2
MC	0.285	-0.003
TPC	0.371	-0.192
CF	-0.147	0.302
TCC	0.394	0.130
GC	0.126	0.205
EGC	0.147	-0.357
C	0.056	0.510
EC	0.113	0.429
EGCG	0.403	0.002
GCG	0.275	0.190
ECG	0.197	0.394
DPPH	0.366	-0.141
FRAP	0.376	-0.170

Sample	w1	w2
O12OT-1	-2.191690977	-1.94102
O12OT-2	-1.185303723	0.997909
O12OT-3	-3.66751768	-0.96079
O12OT-4	-0.759554043	4.084407
O12OT-5	-1.171062354	-1.15137
O12OT-6	1.486714113	-0.17606
O12OT-7	2.98266207	-0.53812
O12OT-8	2.821589779	-0.47704
O12OT-9	1.827804692	-0.12521

Sample O17-OT, N=17

Code	z1	z2	z3	z4	z5	z6	z7	z8	z9	z10	z11	z12	z13
1	-0.41474	0.9579	-1.00733	1.069298	0.41292	1.390625	-0.33953	0.221558	0.753989	-0.64711	0.285949	-0.31485889	0.000666
2	1.601894	-0.11669	-0.02785	0.650307	-0.14366	0.775077	-0.8304	-0.33995	1.013073	0.479703	0.232612	-0.759325955	-0.54951
3	1.290308	0.048202	-1.16725	0.132403	0.328088	0.90464	-0.14736	0.328531	-0.01356	-0.78007	-0.37602	-0.805235235	-0.78141
4	-0.43696	-0.81318	-1.35641	-0.3848	0.046186	0.628638	-0.19512	0.286659	-0.27327	-1.07823	-0.43311	-1.84519688	-1.48641
5	-0.80914	1.636787	2.129703	0.364621	-0.32998	-0.47439	1.436379	0.874125	0.609013	0.73834	2.142094	-1.122477136	0.06018
6	-0.37668	-0.01649	0.150736	0.875305	0.400448	0.531463	-0.44883	-0.04408	0.960085	1.234969	0.462132	-0.903463217	-0.63859
7	-0.76036	0.478238	-0.38045	0.540668	-3.65486	-2.67647	-3.14266	-3.41089	-2.53853	-2.94516	-2.50029	-0.801698431	-1.32476
8	1.334464	0.070526	-0.4383	-2.23963	0.796568	-1.32652	0.729012	0.848115	-1.66376	-0.37861	-1.23581	0.606279033	0.61992
9	-0.38489	-0.33935	-0.78956	-1.78264	0.572641	-1.12287	0.587865	-0.02458	-1.15535	0.000883	-0.15242	1.129863859	0.174294
10	-0.34345	-0.79226	-0.55335	-0.01053	0.05031	0.429222	0.07723	0.075773	0.124372	0.148086	-0.16137	0.226110995	-0.53718
11	-0.81698	0.753264	0.055297	0.759762	0.327782	0.542763	0.379862	0.378915	0.712046	0.228487	0.529713	1.492381504	0.930288
12	-0.8064	-0.93277	-0.65214	-0.39148	0.295742	0.050045	-0.46601	-0.67242	0.219151	0.242063	-0.25401	0.311305394	0.135201
13	1.353891	-0.34198	0.50829	-0.52923	-0.03608	-0.14377	0.007228	-0.14583	-0.04998	0.652683	-0.14853	0.438183206	0.799922
14	-0.37192	-1.60044	-0.01486	-0.71799	0.344703	-0.29807	0.113515	0.025578	-0.29807	0.296701	-0.22413	-0.35294637	-0.89753
15	-0.62365	2.032697	1.979849	1.727081	0.020502	0.785055	0.773008	1.088322	1.330778	1.030915	1.559749	1.584013155	2.384041
16	-1.15765	-1.50643	0.528676	-0.4628	-0.27675	-0.41796	0.55237	-0.28674	0.238291	0.971932	0.04324	-0.177407321	-0.2748
17	1.722283	0.481993	1.034961	0.399662	0.845455	0.422531	0.913434	0.796913	0.031725	-0.19559	0.230193	1.294472287	1.38567

```
Eigenanalysis of the Correlation Matrix

Eigenvalue  4.9072  3.3807  2.0022  1.0205  0.8669  0.3462  0.2200  0.1254
Proportion   0.377   0.260   0.154   0.078   0.067   0.027   0.017   0.010
Cumulative   0.377   0.638   0.792   0.870   0.937   0.963   0.980   0.990

Eigenvalue  0.0671  0.0372  0.0177  0.0089  0.0000
Proportion   0.005   0.003   0.001   0.001   0.000
Cumulative   0.995   0.998   0.999   1.000   1.000
```

```
Variable      PC1     PC2
MC         -0.075  -0.193
TPC         0.370  -0.225
CF          0.389  -0.089
TCC         0.313   0.328
GC         -0.134  -0.296
EGC         0.111   0.373
C           0.220  -0.387
EC          0.252  -0.314
EGCG        0.296   0.396
GCG         0.246   0.110
ECG         0.404   0.129
DPPH        0.158  -0.327
FRAP        0.360  -0.169
```

Sample	w1	w2
O17-OT-1	0.583836	-0.97051
O17-OT-2	0.166462	-0.48455
O17-OT-3	-0.58691	0.689922
O17-OT-4	-1.70331	0.762783
O17-OT-5	2.449394	-1.76749
O17-OT-6	0.782467	-0.80138
O17-OT-7	-7.41045	-3.02984
O17-OT-8	-0.75721	2.94151
O17-OT-9	-0.62208	2.002152
O17-OT-10	-0.18035	0.510604
O17-OT-11	1.778888	-0.74673
O17-OT-12	-0.53465	0.47115
O17-OT-13	0.415909	0.697352
O17-OT-14	-0.71788	1.265563
O17-OT-15	4.266085	-2.45011
O17-OT-16	-0.022	0.417045
O17-OT-017	2.091803	0.492541