International Journal of Pharmaceutical Sciences and Drug Analysis

E-ISSN: 2788-9254
P-ISSN: 2788-9246
IJPSDA 2021; 1(2): 39-43
Received: 05-06-2021
Accepted: 11-07-2021

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Phytochemical and biological properties of *Camellia sinensis*: A review

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Abstract
Green tea (*Camellia sinensis*) has many of health benefits for human. It has possible benefits include promotion of cardio-vascular health, cancer prevention, skin protection, and antioxidant activity, to fight high cholesterol levels, infection, impaired immune system, diarrhoea, fatigue and much more. Its useful antioxidant property exists with their huge collection of chemical substances called polyphenols and catechins make the major contribution to them. It has certain minerals and vitamins increases the antioxidant potential of this type of tea. This present review gave some of the phytochemical constituents and pharmacological activities of this plant.

Keywords: *Camellia sinensis*, chemical compounds, plants, bioactivities

Introduction
Camellia sinensis (Green Tea) is a species of evergreen angiosperm dicot plant whose leaves and leaf buds are used to produce flourishing tea. It is of the genus Camellia of flowering plants in the family Theaceae. It is native to mainland China, South and Southeast Asia [1]. Green tea has more catechins than black tea or oolong tea. Catechins are *in vitro* and *in vivo* strong antioxidants. In ddition, its content minerals and vitamins increase the antioxidant potential of this type of tea. Presently, it is cultivated in at least 30 countries around the world. Tea beverage is an infusion of the dried leaves of *Camellia sinensis.* It is a widely used medicinal plant by the throughout India, China and popular in the various indigenous system of medicine like Ayurveda, Unani and Homoeopathy [1]. Tea made from the leaves of *Camellia sinensis* is one of the most consumed beverages in the world. Teas can be classified depending on the degree of fermentation as green tea (unfermented tea), white tea and yellow tea (lightly fermented), oolong tea (semi-fermented tea), black tea (fermented tea), and pu-erh tea (post-fermented tea). Black tea is the most produced and consumed tea worldwide (78% of total tea, especially in Western countries) followed by green tea (20%, especially in China, India, and Japan) and oolong tea (<2%) [2]. Flavanols (primary catechin compounds such as epigallocatechin gallate), flavonols and glycosyl derivatives (i.e., apigenin, myricetin, quercetin, rutin), teaflavins and thearubigins have been identified as main bioactive compounds in the leaves of *Camellia sinensis*. The type and amount of these compounds is determined by the degree of fermentation of the leaves. Epigallocatechin-3-gallate is the major compound in green tea and theaflavins are produced during the processing of black tea, providing the characteristic flavor [3]. The health benefits of *Camellia sinensis* teas include antioxidant, anti-inflammatory, anti-cancer, cholesterol lowering, and cardiovascular protection properties, among others [3]. The present systematic review gave the phytochemicals and the pharmacological activity of *Camellia sinensis.*

Phytochemicals
The chemical components of tea leaves include alkaloids (caffeine, theobromine, theophylline, etc.), polyphenols including flavonoids and phenolic acids, polysaccharides, amino acids, lipids, vitamins (e.g., vitamin C), inorganic elements (e.g., aluminium, fluorine and manganese), etc. show a variety of bioactivities. Flavonoids are a group of phenolic compounds with several sub-classes: anthocyanidins, flavanones, flavanols, flavones, flavonols and isoflavones.

Polyphenols and catechins
Tea shoots are extremely rich in polyphenolc compounds and the total polyphenols in tea flush ranges between 20 and 30% on a dry weight basis.

The polyphenols in tea mainly include the following six groups of compounds: flavanols, hydroxyl-4- flavonols, anthocyanins, flavones, flavonols and phenolic acids. Among these, catechins (flavan-3-ols) are the most important and occupy 60–80% of the total amount of polyphenols in tea [4]. Several studies showed wide range of total polyphenols depend on countries and geographic origins. The important biochemicals in determining tea quality include the green leaf tea catechins, their oxidation products and caffeine. Nonetheless, a premediated selection among the germplasm with high quality has been lacking. There are sixmajor catechins in tea leaf, 000catechin (C), (-)-epicatechin (EC), (-)-epicatechin gallate (ECG), (?)-gallocatechin (GC), (-)-epigallocatechin (EGC) and (-)-epigallo- catechin gallate (EGCG) [4].

Alkaloids

Among the alkaloids, caffeine (1,3,7-trimethylxanthine), theobromine (3,7-dimethylxanthine) are two major alkaloids and trace amount of theophylline (1,3-dimethylxanthine) also have been detected in tea. Other purine alkaloids, such as theacrine, have also been detected. A study conducted using fresh leaves, theophylline was detectable in the bud and the first leaf (1.3–1.8 mg g-1) but not in the second or third leaf [5]. Various amount of caffeine and its precursor theobromine content have been observed in different tea growing countries. Caffeine is the most abundant alkaloid in tea and the content is usually between 15 and 50 mg /g. Wide variations in caffeine content were observed in tea germplasm collections in various tea growing countries [5].

Flavonols and their glycosides

Flavonoids are known as secondary metabolites which are the largest class of polyphenols widely distributed in the plant kingdom. Tea is a good source of flavonols and the flavonols exist as flavonol glycosides with a sugar residue [6]. The most common flavonol aglycones in tea are quercetin, kaempferol andmyricetin [7]. In a recent study, significant amounts of myricetin, quercetin, and kaempferol have been quantified in the beverage type tea accessions of the Sri Lankan tea germplasm with the average values of fresh leaf flavonol content of var. sinensis, var. assamica and subsp. lasiocalyx recorded 4.43, 3.73 and 3.69 mg g-1, respectively [8]. The composition and content of flavonol and flavones glycosides have been determined in Chinese tea varieties.

Phenolic acids and derivatives

Gallic acid is the predominant phenolic acid, and theogallin (5-galloylquinic acid) is of interest not only because of its unique occurrence in tea but also due to its high contents and correlation to the quality of tea [9]. Tea leaves contain up to 4.5 mg g-1 fresh weight of gallic acid. Among different types of tea, Chinese pu-erh teas contain the highest amount (* 15.5 mg g-1 of dry weight) of gallic acid [10]. Gallic acid forms esters with catechins and esterification with gallic acid is known as galloylation of catechins. The galloylation is mediated by the enzyme, flavan-3-ol gallate synthase (Ashihara *et al*. 2010). In fresh leaves,gallic acid of 87 beverage type tea cultivars and fournon-beverage type accessions have been measured (0.07–1.49 mg g-1) in Sri Lanka [11].

Amino acids

Among essential amino acids, alanine, arginine, asparagine, aspartic acid, glutamic acid, isoleucine, histidine, leucine, phenylalanine, serine, proline, threonine, and tyrosine have been determined by HPLC in green, white, black, and pu-erh teas [12]. There are 19 kinds of amino acids recognized in the tea leaves and they constitute 1–4% the composition, in which theanine, glutamic acid, aspartic acid, serine and arginine cover more than 50% the amount of free amino acids. Among the amino acids, theanine (N-ethylglutamic acid) has attracted most interest for a long time as it is occurs (nearly) exclusively in tea and accounts for as much as 50% of the free amino acids in tea [13].

Organic acids and fatty acids

Oxalic, malic, citric, isocitric and succinic acids are the predominant organic acids in fresh tea leaf [14]. The occurrence of quinic and shikimic acids in tea flush has been demonstrated, in keeping with their role as precursors of polyphenols [15].

Biological activities

Antioxidant effect

Green tea which is essential source for providing polyphenol antioxidants has the ability to protect against various oral diseases such as dental caries, gingivitis, periodontitis, halitosis and oral malignancy (protection and regression). In addition it can prevent from oral oxidative stress, inflammation resulting due to cigarette smoke and reduces dentinerosion and abrasion. Green tea plays supportive role in the maintenance of periodontal health, as suggested by an *in vitro* study catechins (e.g. EGCG) restrict the development and colonization of harmful bacteria such as *Porphyromonas gingivalis*, Prevotella intermedia, and Prevotella nigrescens [16]. These bacteria cause severe harm to periodontal tissues for example *Porphyromonas gingivalis* develop adhesion to buccal mucosa and cause destruction [17]. Recently, Nadeem *et al*. [18] studied the influence of green tea consumption versus black tea on periodontal health of 240 dental students and noticed that students who were consuming green tea had good periodontal health status with minimal plaque accumulation in comparison with consumers of black tea. Literature exhibited that better periodontal health status of regular green tea using individuals is mainly due to catechins, as these are steric structures of 3-galloyl radial, ECG, EGCG and gallocatechin gallate (GCG) (major polyphenols) and responsible for restrain release of toxic end metabolites from *Porphyromonas gingivalis* [19].

Anti-Diabetic potential

Most *in vitro* diabetes studies with *Camellia sinensis* are based on the ability of their isolated compounds and extracts to inhibit -amylase and -glucosidase activity. In addition, there are several *in vitro* studies with cellular models, mouse 3T3-L1 pre/adipocytes and HepG2 cell lines being the most common. Moreover, for *in vivo* studies, preclinical diabetic animal models (Kunming mice, Sprague-Dawley, and Wistar rats) commonly used to investigate the anti-diabetic properties of tea are streptozotocin and alloxan-induced diabetic animals [20, 21]. Clinical trials were randomized, double-blind, and placebo-controlled and they evaluated the hypoglycemic effect of green tea (mainly) and black tea. Most of these works included patients of both sexes (except one with overweight women) and aged between 30 and 80 years. The duration of the treatments varied from weeks to months and the doses/day administered were also di erent in each clinical trial (i.e., 1 g/day; 2.5 g/three times day; 560

mg tea polyphenols/two times day; 200 mg tea extract/day). The parameters measured were different, being analyzed from biochemical parameters such as blood glucose levels to oxidative stress markers. Doses of 1 g of dry extract of green tea and 2.5 g/three times day of black tea for 12 weeks were effective to improve glycemic control even better than the reference drug metformin [22, 23]. Moreover, both 560 mg tea polyphenols/two times day for 20 weeks and 200 mg tea extract/day for 9–18 months had an antioxidant effect as evidenced in an increase of superoxide dismutase activity and a decrease of lipid peroxidation [24, 25].

Anti -Hypertensive effect

In a study, pretreatments with black tea extract (0.3–5 µg/mL) and theaflavin-3,3'-digallate (0.03–0.5 g/mL) for 30 min improved endothelium dependent relaxations in homocysteine (endoplasmic reticulum stress inductor) treated cultured rat aortic endothelial cells [26]. The effect of black tea extract (15mg/kg/day for 2 weeks) in a rat model of angiotensin II. This study revealed that black tea extract prevented elevated plasma homocysteine levels and downregulated endoplasmic reticulum stress markers. Furthermore, Nomura *et al*. (2017) [27] investigated the protective effect of three different cultivars of *Camellia sinensis* in a model of hypertensive rats fed with a high salt diet. All these tea cultivars reduced urinary NO metabolite and, moreover, "Yabukita" and "Sofu" increased soluble guanylate cyclase expression. Finally, a single clinical trial has been identified in which the effect of tea, compared with co ee, on blood pressure was evaluated. This study (1352 subjects aged 18–69 years) stratified population in three groups (non-consumers, 3 dL/d consumers, and >3 dL/dconsumers of tea. Results showed that consumption of 1 dL/day of tea was associated with lower systolic blood pressure (by 0.6 mm Hg) and lower pulse pressure (by 0.5 mm Hg) [28].

Anti-Obesity potential

The mouse adipocyte 3T3-L1 cell line has been extensively used to study the *in vitro* effect of tea extracts and its isolated compounds [29]. In obesity *in vivo* studies, C57BL/6J mice are the most widely animal model since they are susceptible to high fat diet-induced obesity [30, 31]. Moreover, other experimental animal models have been used to investigate the effects of different kind of teas and isolated compounds on obesity including Wistar rats, Sprague-Dawley rats, and Swiss mice fed with a high fat diet [32, 33].

Anti-Osteoporosis potential

Green tea extract (25, 50, and 100 µg/mL, 48 h) has shown to inhibit RANKL-induced osteoclast formation in the mouse macrophage-like cell line RAW264.7 related to NFATc1, cathepsin K, C-Fos, and MMP-9 gene levels reduction [34]. Moreover, the isolated compound gallocatechin gallate (oxidation product of epigallocatechin-3-gallate) at 10 µM concentration inhibited osteoclastogenesis more potently than epigallocatechin-3-gallate through gene and protein downregulation (TRAP, c-Src,3-Integrin, cathepsin K, and MMP-9) and master transcriptional regulators downregulation (NFATc1 and c-Fos) in RAW264.7 cells [35]. Redox imbalance is also involved in the pathogenesis of bone loss. Overproduction of ROS increases osteoclast activity and inhibits mineralization [36]. Flavones from tea have demonstrated to act as antioxidants. Particularly, epicatechin isolated from Huangshan Maofeng tea (green tea produced in Anhui province of China) has shown to protect against oxidative stress in a hydrogen peroxide-induced model on C2C12 mouse myoblast cells [37]. Moreover, *in vivo* evidence has demonstrated that tea exerts a protective effect on osteoporosis as evidenced in relevant biomarkers. Hence, green tea extracts (dose of 370 mg/kg for 13 weeks) increase cortical and trabecular bone mass in ovariectomized femaleWistar rats [38]. Furthermore, green tea polyphenols supplementation (4 months) improved bone properties (alleviate bone loss and favored bone microstructure restructuring) in obese rats fed with a high fat diet and a high fat diet followed by a caloric restricted diet [39].

Conclusion

Green tea is consumed throughout the world in various forms. The years of safe consumption of this beverage, supported by numerous studies showing health benefits, warrant a general recommendation to consume it regularly. It has antioxidant, antidiabetic, antiinflammatory, antibacterial, antiviral and anti-cancer properties. Green tea also acts positively on neurodegenerative diseases such as Parkinson and Alzheimer disease.

References

1. Dattner Christine Boussabba Sophie. Emmanuelle Javelle, ed. The Book of Green Tea. Universe Books. 2003, P.13.
2. Naveed M, BiBi J, Kamboh AA, Suheryani I, Kakar I, Fazlani SA, *et al*. Pharmacological values and therapeutic properties of black tea (*Camellia sinensis*): A comprehensive overview. Biomed. Pharm 2018;100:521-531.
3. Bedrood Z, Rameshrad M, Hosseinzadeh H. Toxicological effects of *Camellia sinensis* (green tea): A review. Phytother. Res 2018;32:1163-1180.
4. Robertson A. The chemistry and biochemistry of black tea production—the non-volatiles. In: Willson KC, Clifford MN (eds) Tea: cultivation to consumption. Chapman& Hall Publication, London, 1992, 555-601.
5. Chen C-N, Liang C-M, Lai J-R. Capillary electrophoretic determination of theanine, caffeine, and catechins in fresh tea leaves and oolong tea and their effects on rat neurosphere adhesion and migration. J Agric Food Chem 2003;51:7495-7503.
6. Hollman PCH, de Vries JHM, van Leeuwen SD. Absorption of dietary quercetin glycosides and quercetin in healthy ileostomy volunteers. Am J Clin Nutr 1995;62:1276-1282.
7. Yao LH, Jiang YM, Shi J, *et al*. Flavonoids in Food and Their Health Benefits. Plant Foods Hum Nutr 2004;59:113-122.
8. Jeganathan B, Punyasiri PAN, Kottawa-Arachchi JD. Genetic variation of flavonols quercetin, myricetin, and kaempferol in the Sri Lankan tea (*Camellia sinensis* L.) and their health-promoting aspects. Int J Food Sci2016:1–9.
9. Hara Y, Luo SJ, Wickremasinghe RL, Yamanishi T. Special issue on tea. Food Rev Int 1995;11:371-545.

10. Lin JK, Lin CL, Liang YC. Survey of catechins, gallic acid, and methylxanthines in green, oolong, pu-erh, and black teas. J Agric Food Chem 1998;46:3635-3642
11. Punyasiri PAN, Jeganathan B, Kottawa-Arachchi JD. Genotypic variation in biochemical compounds of the Sri Lankan tea (*Camellia sinensis* L.) accessions and their relationships to quality and biotic stresses. J Hortic Sci Biotechnol 2017;92:502-512.
12. Wang L, Xu R, Hu B *et al*. Analysis of free amino acidsin Chinese teas and flower of tea plant by high performance liquid chromatography combined with solid-phase extraction. Food Chem 2010a;123:1259-1266.
13. Vuong QV, Bowyer MC, Roach PD. L-Theanine: properties, synthesis and isolation from tea. J Sci Food Agric 2011;91:1931-1939.
14. Sanderson GW, Selvendran RR. The organic acids in tea plants. A study of the non-volatile organic acids separated on silica gel. J Sci Food Agric 1965;16:251-258.
15. Engelhardt UH. Chemistry of Tea. In:Mender L, Liu HW(eds) Comprehensive natural products II: chemistry and biology. Elsevier, London 2010, 999-1032.
16. Makimura M, Hirasawa M, Kobayashi K, *et al*. Inhibitory effect of tea catechins on collagenase activity. J Periodontol 1993;64(7):630-6.
17. Magnusson I, Lindhe J, Yoneyama T, Liljenberg B. Recolonization of a subgingival microbiota following scaling in deep pockets. J Clin Periodontol 1984;11(3):193-207.
18. Nadeem M, Datoo F, Bugti AA, Ayaz A, Mahfooz M. Effects of black tea and green tea on periodontal health status among dental students at pakistan 2014.
19. Sakanaka S, Okada Y. Inhibitory effects of green tea polyphenols on the production of a virulence factor of the periodontal-disease-causing anaerobic bacterium *Porphyromonas gingivalis*. J Agric Food Chem 2004;52(6):1688-92.
20. Kumar D, Rizvi SI. Black tea extract improves anti-oxidant profile in experimental diabetic rats. Arch. Physiol. Biochem 2015;121:109-115.
21. Othman AI, El-Sawi MR, El-Missiry MA, Abukhalil MH. Epigallocatechin-3-gallate protects against diabetic cardiomyopathy through modulating the cardio metabolic risk factors, oxidative stress, inflammation, cell death and fibrosis in streptozotocin-nicotinamide-induced diabetic rats. Biomed. Pharm 2017:94:362-373.
22. Alves Ferreira M, Oliveira Gomes AP, Guimarães de Moraes AP, Ferreira Stringhini ML, Mota JF, Siqueira Guedes Coelho A, *et al*. Green tea extract outperforms metformin in lipid profile and glycaemic control in overweight women: A double-blind, placebo-controlled, randomized trial. Clin Nutr 2017:22:1-6.
23. Mahmoud F, Al-Ozairi E, Haines D, Novotny L, Dashti A, Ibrahim B, *et al*. Effect of Diabetea tea consumption on inflammatory cytokines and metabolic biomarkers in type 2 diabetes patients. J Ethnopharmacol 2016:194:1069-1077.
24. Spadiene A, Savickiene N, Ivanauskas L, Jakstas V, Skesters A, Silova A, *et al*. Antioxidant effects of *Camellia sinensis* L. extract in patients with type 2 diabetes. J. Food Drug Anal 2014:22:505-511.
25. Vaz SR, de Amorim LMN, de Nascimento PVF, Veloso VSP, Nogueira MS, Castro IA, *et al*. Effects of green tea extract on oxidative stress and renal function in diabetic individuals: A randomized, double-blinded, controlled trial. J Funct. Foods 2018;46:195-201.
26. San Cheang W, Yuen Ngai C, Yen Tam Y, Yu Tian X, TakWong W, Zhang Y, *et al*. Black tea protects against hypertension-associated endothelial dysfunction through alleviation of endoplasmic reticulum stress. Sci. Rep 2015;15:10340.
27. Nomura S, Monobe M, Ema K, Maeda-Yamamoto M, Nesumi A. comparison of the effects of three tea cultivars (*Camellia sinensis* L.) on nitric oxide production and aortic soluble guanylate cyclase expression in high-salt diet-fed spontaneously hypertensive rats. J Nutr. Sci. Vitaminol 2017;63:306-314.
28. Alkerwi A, Sauvageot N, Crichton GE, Elias MF. Tea, but not associated with components of arterial pressure. The observation of cardiovascular risk factors study in Luxembourg. Nutr. Res 2015;35:557-565.
29. Li KK, Peng JM, Zhu W, Cheng BH, Li CM. *Gallocatechin gallate* (GCG) inhibits 3T3-L1 differentiation and lipopolysaccharide induced inflammation through MAPK and NF- B signaling. J Funct. Foods 2017;30:159-167. [CrossRef]
30. Heber D, Zhang Y, Yang J, Ma JE, Henning SM, Li Z. Green tea, black tea, and oolong tea polyphenols reduce visceral fat and inflammation in mice fed high-fat, high-sucrose obesogenic diets. Nutr. J 2014;144:1385-1393.
31. Yuan E, Duan X, Xiang L, Ren J, Lai X, Li Q *et al*. Aged oolong tea reduces high-fat diet-induced fat accumulation and dyslipidemia by regulating the AMPK/ACC signaling pathway. Nutrients 2018, 10, 187.
32. Hamdaoui MH, Snoussi C, Dhaouadi K, Fattouch S, Ducroc R, Le Gall M, *et al*. Tea decoctions prevent body weight gain in rats fed high-fat diet; black tea being more effcient than green tea. J. Nutr. Intermed. Metab 2016;6:33-40.
33. Liu C, Guo Y, Sun L, Lai X, Li Q, Zhang W, *et al*. Six types of tea reduce high-fat-diet-induced fat accumulation inmice by increasing lipid metabolism and suppressing inflammation. Food Funct 2019;10:2061-2074.
34. Wu X, Xie CQ, Zhu QQ, Wang MY, Sun B, Huang YP, *et al*. Green tea (*Camellia sinensis*) aqueous extract alleviates postmenopausal osteoporosis in ovariectomized rats and prevents RANKL-induced osteoclastogenesis *in vitro*. Food Nutr. Res. 2018, 62, 1478–1489.
35. Xu H, Liu T, Li J, Xu J, Chen F, Hu L, *et al*. Oxidation derivative of (-)-epigallocatechin-3-gallate (EGCG) inhibits RANKL-induced osteoclastogenesis by suppressing RANK signaling pathways in RAW 264.7 cells. Biomed. Pharm 2019;118:109237.
36. Domazetovic V, Marcucci G, Iantomasi T, Brandi ML, Vincenzini MT. Oxidative stress in bone remodeling: Role of antioxidants. Clin. Cases Min. Bone Metab 2017;14:209-216.
37. Zeng X, Tian J, Cai K, Wu X, Wang Y, Zheng Y, *et al*. Promoting osteoblast dierentiation by the flavanes from Huangshan Maofeng tea is linked to a reduction of oxidative stress. Phytomedicine 2014;21:217-224.
38. Xu H, Yin D, Liu T, Chen F, Chen Y, Wang X, *et al*. Tea polysaccharide inhibits RANKL-induced

osteoclastogenesis in raw264. 7 cells and ameliorates ovariectomy-induced osteoporosis in rats. Biomed. Pharm 2018;102:539-548.
39. Shen CL, Han J, Wang S, Chung E, Chyu MC, Cao JJ. Green tea supplementation benefits body composition and improves bone properties in obese female rats fed with high-fat diet and caloric restricted diet. Nutr. Res 2015:35:1095-1105.