MEDICINAL CHINESE TEAS:
A review of their health benefits with a focus on fermented tea

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Scientists from Hunan City University prepare experimentally fermented fuzhuan tea for taste-testing. Photo ©2012 Tiffany Weir

Summary

Tea has been enjoyed globally for centuries as a beverage and for its unique medicinal properties. Scientific investigations of the active chemical compounds in tea and their biological mechanisms of action support continued human studies on the prevention and amelioration of chronic diseases. The distinction between different types of teas and their reported health benefits can often be misleading and has been reviewed herein to highlight physical and chemical differences. Because the enzymatic oxidation process is often mistakenly referred to as fermentation, the term "post-fermented" is used to distinguish between teas that have undergone an open-air microbial fermentation step from those teas that have been oxidized only. These post-fermented teas have been ignored largely by Western researchers and are presented as a novel focus area of this review. The emphasis on fuzhuan tea is a result of research conducted in China that suggests that the active components of this tea differ from the catechins and L-theanine that contribute to the bioactivity of green, black, and other kinds of tea. Observational human data suggest that this tea may have unique health properties and that it merits future controlled human clinical trials on the prevention, control, and treatment of cardiovascular disease and Type 2 diabetes.

Introduction

According to Chinese lore, tea was first discovered nearly 5,000 years ago when leaves from a nearby tea tree blew into a cup of warm water belonging to the emperor Shen Nong. From its ancient origins, tea consumption has grown and it is now second only to water in worldwide beverage consumption. It continues to gain popularity in North America because of reported health benefits, including weight loss, chemoprevention, improved immune function, and decreased risk of cardiovascular disease and diabetes.[1-4]

Despite its widespread and rapidly growing popularity, there is considerable confusion regarding what constitutes a tea, differences among types and processing of teas, and their level of oxidation and fermentation. This review is intended to clarify these important distinctions and to introduce fuzhuan tea (also called Golden Flower, Hu Nan Hei Cha, Huajuan, and Hu or Fu Brick tea), a unique type of post-fermented tea from China. Observational results from Asian populations who eat high-fat, meat-based diets, but also consume fuzhuan tea daily, strongly suggest lipid

Tea *Camellia sinensis.* Photo ©2012 Steven Foster

protective/lowering effects of this tea.[5,6] These observations have led to pre-clinical studies in models of hyperlipidemia.[5,6] Human observational studies in the United States are underway to address whether fuzhuan tea can alter blood lipid profiles (*i.e.,* lowering low-density lipoprotein [LDL], raising high-density lipoprotein [HDL], altering particle size). Accumulating scientific evidence suggests that this post-fermented tea may become a viable alternative to statins and other medications. It may have utility as a dietary supplement for individuals with elevated cholesterol who are at high risk for cardiovascular disease and plan to manage disease risk without medication.[7]

Tea Origins and Processing

Tea is a beverage made from the leaves, buds, stems, and nodes of the plant *Camellia sinensis* (Theaceae), an evergreen shrub originating from Southeast Asia, which is now cultivated in tropical and subtropical regions worldwide. Beverages made of chamomile (*Matricaria recutita*, Asteraceae), echinacea (*Echinacea purpurea*, Asteraceae), yerba mate (*llex paraguariensis*, Aquifoliaceae), and other herbs, for example, are frequently referred to as teas, although they contain no *C. sinensis* and are more accurately called infusions or tisanes.[8,9] Although there are several varieties of *C. sinensis*, only two of these make up the majority of commercial tea production. These major varieties are *C. sinensis* var. *sinensis,* which originated in China, has smaller leaves, and grows at higher altitudes; and *C. sinensis* var. *assamica,* a larger-leafed variety from the Assam region of India that is adapted to lower elevation. Other varieties include *C. sinensis* var. *parvifolia*, a lesser known hybrid of *assamica* and *sinensis*; *C. sinensis* var. *cambodiensis,* "the Java bush;" and *C. sinensis* var. *waldenae*, which had been considered a separate species but recently was reclassified as a variety of *C. sinensis*.[10] For the tea drinker, typically the beverage is distinguished more by the steps that go into processing the teas than the variety of plant used (Figure 1). Depending on the age of the leaves, the extent of oxidation, post-harvest treatment, and quality of the final product, currently most teas are classified as white, green, yellow, oolong, black, and dark teas.

The steps of tea processing include wilting, rolling, oxidation, heat fixing (a step to stop the oxidation process), yellowing (only with yellow tea), shaping, drying, and curing. A tea is classified depending on the number and sequence of these steps that it undergoes. Wilting is a process by which newly picked leaves are thinly spread to air dry. In areas where the climate is too moist, heated air is forced through the leaves. This step reduces the water content of the leaves, but they remain pliable enough for rolling. Rolling of the leaves is conducted either by machine or by hand to break the cells, releasing oils that give the tea its distinctive aroma. Rolling can also activate enzymes in the cells resulting in oxidation of the leaves and is not to be confused with the microbial fermentation process exclusive to post-fermentation tea processing. During oxidation, the chlorophyll is broken down, causing the leaves to turn brown and release tannins. The oxidation is stopped by a drying step, which evenly dries the leaf without burning it and inactivates the enzymes that result in oxidation. Green, yellow, oolong, white, and black teas are primarily determined by their level of oxidation, while all dark teas undergo a microbial fermentation step and are usually sold as bricks or cakes. Green, dark, and yellow teas may or may not be wilted, and are then pan-fried or steamed (heat-fixed) to prevent oxidation, resulting in leaves that remain green. Black teas are rolled and fully oxidized, while oolong teas are often shaken rather than rolled and then only partially oxidized before drying. White tea is the least processed form of tea. It is made from buds and young leaves of plants that are picked in early spring and air-dried to prevent oxidation.

Tea Polyphenols and Health Benefits

As a result of the different processing methods, each type of tea has a different chemical content that results in distinctive flavors,

Although most fermented teas are sold in brick or cake forms, loose-leaf tea bags of Hunan Cha are being manufactured for foreign markets.
Photo ©2012 Tiffany Weir

Although the purported benefits of tea polyphenols have been widely touted, the majority of the evidence has been generated from studies in cell lines, animal models, or derived from epidemiological observations, and reports from the existing human clinical trials are conflicting.

colors, and health benefits. In general, the health-promoting properties of green teas are the best-studied and are largely attributed to a class of polyphenolic compounds, including but not limited to the family of catechins comprising the following: epicatechin (EC), epicatechin gallate (ECG), and epigallocatechin gallate (EGCG).[11] Catechins are natural antioxidants that contribute to a number of reported biological activities such as protection against cancer and cardiovascular disease, antimicrobial and antiviral properties, and modulation of obesity and insulin resistance.[12,13] Oolong and black teas, originally valued for their deep, rich flavors, lose many of these beneficial catechin compounds during oxidation.[14, 15] During the oxidation process, catechins are converted to other classes of polyphenolic compounds known as theaflavins and thearubigens, which are potent antioxidants and impart different health benefits than the polyphenols from green teas.[15]

Although the purported benefits of tea polyphenols have been widely touted, the majority of the evidence has been generated from studies in cell lines, animal models, or derived from epidemiological observations, and reports from the existing human clinical trials are conflicting. Inconclusive findings regarding therapeutic or protective effects of teas against cancer and Type 2 diabetes have been summarized in recent meta-analyses.[16,17,18,19] Studies indicating efficacy of tea polyphenols for reducing body fat and lowering lipid levels are equally confounding. Although several human intervention studies have shown that orally administered tea polyphenols result in weight loss, lower body mass index (BMI), and reduced LDL,[20,21] other studies showed significant decrease in body weight but without corresponding reduction in body fat or hip:waist ratios.[22,23] There are many confounding factors that must be accounted for, including human genetics, differences in tea preparation, variation in tea bioactive chemicals, and bioavailability/metabolism of these bioactive components. Furthermore, these results highlight the

Table 1. Examples of Different Dark Teas and Their Processing Methods.

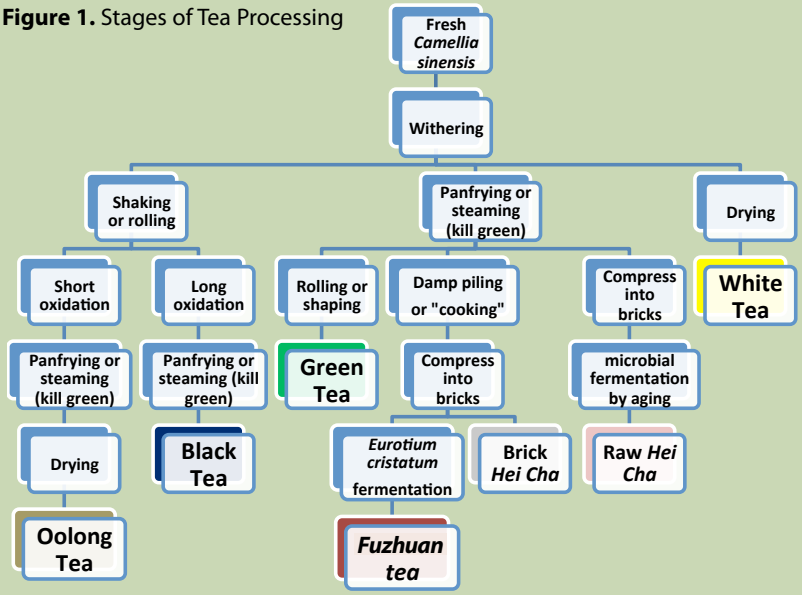
Tea	Province of Origin	Processing Method	Additional information
Liu Bao	Guangxi, Guangong	pile-fermented, aged in bamboo baskets	Partially oxidized *C. sinensis* var. *assamica*
Qing Zhuan	Hubei	pile-fermented	Leaves from older, selenium-enriched plants from the western part of the province
Mi Zhuan	Hubei	natural aging methods	Made from fully oxidized tea leaves
Fuzhuan	Hunan	pile-fermented followed by *E. cristatum* development	Brick forms contain stems and twigs, visible "golden flower"
Hua Juan/ Qian Liang	Hunan	naturally aged and stored in bamboo or palm mats	Processed by hand
Xiang Jian	Hunan	pile-fermented, aged in bamboo baskets	Harvested during the "Grain rain" season, no step to stop oxidation
Kang Zhuan	Sichuan	pile-fermented	
Pu'erh	Yunnan	naturally aged or pile-fermented	**Connoisseur's tea, *C. sinensis* var. *assamica***

need for controlled human studies conducted in diverse populations and clear identification of and amount of the bioactive chemical linked to the specific biological activity under investigation.

Post-Fermented or Dark Teas

In addition to the well-known and widely consumed teas discussed above, a unique processing method that involves microbial fermentation is used for the production of dark or post-fermented tea. Most post-fermented teas start with a process to stop oxidation, similar to green tea, but are then subjected to a microbial fermentation step that gives the leaves a darker color and alters their flavor. Raw dark teas are steamed and compressed into cakes or bricks (zhuan) and aged over a period of years. These rare and expensive age-fermented teas are highly coveted by tea connoisseurs, although their origins are much more humble. Traditionally, these teas were compressed to facilitate their transport by donkey or horse and preserve them for trade to the northwestern provinces where natural fermentation would occur by common microbes such as *Sacchromyces* spp. (Saccharomycetaceae; brewer's yeast) and *Aspergillus spp.* (Trichocomaceae; bread molds). These teas were historically traded by way of the "Tea Horse Road" and were highly valued for their health properties among nomadic populations who largely consumed high-fat and protein-based diets.[24]

Figure 1. Stages of Tea Processing



Post-fermented brick teas differ from raw dark teas because they undergo a multi-step curing process referred to as "cooking" or "ripening." Cooking consists of piling, dampening, and turning the leaves in a manner similar to compost, resulting in a much faster secondary fermentation while replicating the taste of naturally aged raw-brick teas. Post-fermented teas are not to be confused with kombucha, a fermented beverage of Russian origin. Kombucha is made by adding a symbiotic colony of bacteria and yeast (scoby) to ferment an infusion made with tea leaves or herbs and sweetened with sugar. The scoby usually contains various yeasts and acetic acid-producing bacteria, such as *Gluconacetobacter xylenus* (Acetobacteraceae), which converts the alcohols produced by the yeasts into acetic acid.[25]

Figure 2. Production of fuzhuan tea. (A) Harvest of *Camellia sinensis* leaves in Hunan province. (B) After oxidation is stopped by steaming, an initial fermentation step occurs by damp piling the tea leaves. (C) Tea leaves are re-steamed and compressed into bricks. (D) Fuzhuan bricks are subjected to an additional fermentation process where its distinguishing feature, the visible yellow fungal colonies (inset) of *Eurotium cristatum* develop.
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Outside of China, Pu'erh tea is the most popular dark tea and its origins, processing, and health benefits have been reviewed recently.[24] Many westerners believe that Pu'erh is synonymous with fermented dark teas, and a significant point of clarification and synthesis for this review is that Pu'erh is only one of several specific types of post-fermented brick tea. Other brick teas include Hei zhuan, Mi zhuan, Kang zhuan, Qing zhuan, Liu bao, Hua zhuan, and Fuzhuan tea. While these post-fermented teas are considered to be similar, they are distinguished by their region of origin and methods of fermentation (Table 1). Fuzhuan tea comes from Hunan Province, China, and undergoes a consistent and regulated modern process of post-fermentation (Figure 2). This post-fermented tea is produced by the damp-piling method, but unlike the other post-fermented teas that widely vary in microflora from factory to factory, fuzhuan tea is also intentionally fermented with a fungus, *Eurotium cristatum* (Trichomaceae),

Fungal growth of *Eurotium cristatum*, the "Golden Flower," is visible as a yellow powder on fuzhuan tea leaves. Photo ©2012 Tiffany Weir

called the "golden flower" (Figure 2D). This fungus, originally isolated and described in association with stored corn in South Africa[26] is the dominant micro-organism present during fermentation of fuzhuan tea.[27] *Eurotium cristatum* is closely related to molds in the genus *Aspergillus,* a group of fungi that has a wide range of industrial uses[28,29] and whose consumption is generally regarded as safe (GRAS) by the US Food and Drug Administration.[30] Fermentation of tea leaves by *E. cristatum* is thought to impart unique chemical properties and bioactivity to fuzhuan tea, and the quality of a brick is often determined by the prevalence of "golden flowers" on its surface.

Interestingly, fermentation by *E. cristatum* has been shown to reduce the amount of catechins, caffeine, and amino acids found in fuzhuan tea, and the levels of theaflavin and thearubigin vary dramatically.[31] Thus, this tea has lower levels of the compounds thought to impart bioactivity than other teas.[32,33] However, a recently published report identified several novel triterpenoid compounds from fuzhuan tea, but their significance as bioactive components of the tea has not yet been determined.[34] In addition, *E. cristatum* produces unique fungal metabolites, such as anthraquinone pigments including emodin and catenarin,[35] which have reported bioactivities. Emodin was recently shown to inhibit 11β-hydroxysteroid dehydrogenase type 1 (11β-HSD1), a promising therapeutic target in type 2 diabetes, and also reduced prednisone-induced insulin resistance in a diet-induced diabetic mouse model.[36] Catenarin, the most abundant anthraquinone detected in the mycelia and the culture filtrates of *E. cristatum* has antimicrobial properties.[35,37] The authors' laboratories are currently exploring chemical differences between fuzhuan tea and a variety of green teas and have tentatively identified several fatty acid amides (Keller *et al.*, unpublished data) that are catabolically related to cannabinoids and are thought to promote sleep.[38]

Despite lower levels of the polyphenols believed to impart tea's health-promoting effects, results from several *in vitro* and *in vivo* animal studies indicate that fuzhuan tea and its extracts show activity in reducing hyperlipidemia.[5,6,32] In addition, the tea was shown to be active at inhibiting growth of 2 gastrointestinal cancer cell lines.[39] A recently published study reporting observational data from 10 individuals showed that individuals who consumed the tea for 120 days showed significantly lower total cholesterol, LDL, and HbA1c levels, and higher HDL when compared to historical controls.[7] Although further studies are needed to assess the clinical efficacy of this tea for cancer and cardiovascular benefits, *in vitro* activities and phytochemical characterization suggest that the biological activity of this tea may be due to novel compounds resulting from *E. cristatum* fermentation.

Conclusion

The study of fuzhuan tea has been at the forefront of tea research throughout China, but has not been available for scientific study and consumption in the United States until recently. In addition to compelling data suggesting that this tea can regulate blood sugars and cholesterol,[7] fuzhuan tea has been shown in Chinese studies *in vitro* and in animal and human models to promote weight loss,[5] aid in digestion,[40] prevent certain gastric cancers,[39] and treat secretory diarrhea.[41] Future studies on fuzhuan tea will be focused on identifying novel active chemical components and their cellular targets, and on identifying the tea's ability to modulate native microflora in the gut. A healthy gut flora aids in digestion, prevents pathogen colonization, and modulates mucosal and systemic immune responses and inflammation.[42] Promotion of healthy commensal bacteria by fuzhuan tea could provide a mechanism for the broad range of reported effects of this tea. Ultimately, controlled human clinical studies will also be needed to validate the various ethnobotanical medicinal uses of this tea. HG

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Disclosure: Paul V. Murray and Wenying Lin distribute fuzhuan tea under the trade name PHatea.

References

1. Widlansky ME, Duffy SJ, Hamburg NM, et al. Effects of black tea consumption on plasma catechins and markers of oxidative stress and inflammation in patients with coronary artery disease. *Free Radic Biol Med.* 2005;38(4):499-506.
2. Schneider C, Segre T. Green Tea: Potential Health Benefits. *Am Fam Physician.* 2009;79:591-594.
3. Cooper R, Morre DJ, Morre DM. Medicinal benefits of green tea part I. Review of Non Cancer Health Benefits. *J Altern Complement Med.* 2005;11:521-528.
4. Cooper R, Morre DJ, Morre DM. Medicinal benefits of green tea part II. Review of AntiCancer Properties. *J Altern Complement Med.* 2005;11:639-652.
5. Xiao WJ, Ren GP, Fu DH, Gong ZH, Xiao LZ, Liu ZH. Study on the regulation of blood lipid by fuzhuan tea. *Cha Ye Ke Xue.* 2007;27:211-214.
6. Fu DH, Liu ZH, Huang J, Gong YS, Chen JH. Research of fuzhuan tea's therapy for hyperlipidemia by high-throughput screening. *Cha Ye Ke Xue.* 2006;26:209-214.
7. Fu D, Ryan EP, Huang J, et al. Fermented *Camellia sinensis*, fuzhuan tea, regulates hyperlipidemia and transcription factors involved in lipid catabolism. *Food Res Int.* 2011:in press.
8. Martin LC, Cooper R. From herbs to Medicines: a world history of tea—from legend to healthy obsession. *Alternative and Complementary Therapies.* 2011;17(3):162-168.
9. Martin LC. *Tea, the Drink that Changed the World*. Atlanta: Tuttle Publishing; 2007.
10. Ming TL. A revision of Camellia sect. *Thea. Acta Botanica Yunnanica.* 1992;14:115-132.
11. Lunder TL. Catechins of green tea: antioxidant activity. *Phenolic compounds in food and their effects on health.* American Chemical Society; 1992.
12. Zaveri NT. Green tea and its polyphenolic catechins: medicinal uses in cancer and noncancer applications. *Life Sci.* 2006;78(18):2073-2080.
13. Liao S, Kao Y-H, Hiipakka RA. Green tea: biochemical and biological basis for health benefits. *Vitam Hormon.* Vol Volume 62: Academic Press; 2001:1-94.
14. Lin Y-S, Tsai Y-J, Tsay J-S, Lin J-K. Factors affecting the levels of tea polyphenols and caffeine in tea leaves. *J Agric Food Chem.* 2003;51(7):1864-1873.
15. Leung LK, Su Y, Chen R, Zhang Z, Huang Y, Chen Z-Y. Theaflavins in black tea and catechins in green tea are equally effective antioxidants. *J Nutr.* September 1, 2001 2001;131(9):2248-2251.
16. Iwasaki M, Inoue M, Sasazuki S, et al. Green tea drinking and subsequent risk of breast cancer in a population to based cohort of Japanese women. *Breast Cancer Res.* 2010;12(5):R88.
17. Ogunleye A, Xue F, Michels K. Green tea consumption and breast cancer risk or recurrence: a meta-analysis. *Breast Cancer Res Treat.* 2010;119(2):477-484.
18. Jing Y, Han G, Hu Y, Bi Y, Li L, Zhu D. Tea consumption and risk of type 2 diabetes: a meta-analysis of cohort studies. *J Gen Intern Med.* 2009;24(5):557-562.
19. Kakuta Y, Nakaya N, Nagase S, et al. Case–control study of green tea consumption and the risk of endometrial endometrioid adenocarcinoma. *Cancer Causes Control.* 2009;20(5):617-624.
20. Nagao T, Hase T, Tokimitsu I. A green tea extract high in catechins reduces body fat and cardiovascular risks in humans. *Obesity.* 2007;15(6):1473-1483.
21. Nagao T, Komine Y, Soga S, et al. Ingestion of a tea rich in catechins leads to a reduction in body fat and malondialdehyde-modified LDL in men. *Am J Clin Nutr.* January 1, 2005 2005;81(1):122-129.
22. Diepvens K, Kovacs EMR, Nijs IMT, Vogels N, Westerterp-Plantenga MS. Effect of green tea on resting energy expenditure and substrate oxidation during weight loss in overweight females. *Br J of Nutr.* 2005;94(06):1026-1034.
23. Auvichayapat P, Prapochanung M, Tunkamnerdthai O, et al. Effectiveness of green tea on weight reduction in obese Thais: A randomized, controlled trial. *Physiol Behav.* 2008;93(3):486-491.
24. Ahmed S, Freeman M. Pu'erh tea and the Southwest Silk Road: an ancient quest for well-being. *HerbalGram.* 2011;90:32-43.
25. Nguyen V, Flanagan B, Gidley M, Dykes G. Characterization of cellulose production by a Gluconacetobacter xylinus strain from kombucha. *Curr Microbiol.* 2008;57(5):449-453.
26. Raper, Fennell. *The Genus Aspergillus* 1965.
27. Liu ZY, Xu AQ, Li ZJ, Wang YL. Research progress on *Eurotium cristatum* and its metabolites in fuzhuan tea. *Tea Communication.* 2010;37:23-26.
28. Powell KA. *The genus aspergillus from taxonomy and genetics to industrial application*. New York: Plenum; 1994.
29. Wood BJB. Oriental food uses of Aspergillus. In: Smith JE, Pateman JA, eds. *Genetics and Physiology of Aspergillus*. London: Academic Press; 1977:481-498.
30. US-FDA/CFSAN. Gras Notice Inventory. 11/9/2009; http://www.fda.gov/Food/FoodIngredientsPackaging/GenerallyRecognizedasSafeGRAS/GRASListings/default.htm. Accessed July 20,2011.
31. Huang Q, Li YP, Chen LJ, Chen K. Study of chages in active components in dark tea (fuzhuan tea) during liquid fermentation by Eurotium cristatum. *Journal of Tea Science.* 2007;28(231-234).
32. Fu DH, Liu ZH, Huang JA, Hao F, Wang F, Lei YG. Variations of components of fuzhuan tea during processing. *Cha Ye Ke Xue.* 2008;29:64-67.
33. Zhu QI, Clifford MN, Mao QL, Deng FM. Comparative study on the components of Pu'er tea and Fu-brick tea with black tea by LC-MS. *Journal of Tea Science.* 2006;26:191-194.
34. Ling T-J, Wan X-C, Ling W-W, et al. New triterpenoids and other constituents from a special microbial-fermented tea—fuzhuan brick tea. *J Agric Food Chem.* 2010;58(8):4945-4950.
35. Anke H, Kolthoum I, Zähner H, Laatsch H. Metabolic products of microorganisms. 185. The anthraquinones of the *Aspergillus glaucus* group. I. Occurrence, isolation, identification and antimicrobial activity. *Arch Microbiol.* 1980;126(3):223-230.
36. Feng Y, Huang S-l, Dou W, et al. Emodin, a natural product, selectively inhibits 11β-hydroxysteroid dehydrogenase type 1 and ameliorates metabolic disorder in diet-induced obese mice. *Br J Pharmacol.* 2010;161(1):113-126.
37. Wakuliński W, Kachlicki P, Sobiczewski P, et al. Catenarin production by isolates of Pyrenophora tritici-repentis (Died.) Drechsler and its antimicrobial activity. *J Phytopathol.* 2003;151(2):74-79.
38. Huang J-K, Jan C-R. Linoleamide, a brain lipid that induces sleep, increases cytosolic Ca2+ levels in MDCK renal tubular cells. *Life Sciences.* 2001;68(9):997-1004.
39. Song LB, Huang JA, Liu ZH, Huang H, Wang KB. Study of the activity of dark (fuzhuan) tea to gastrointestinal tumor. *Cha Ye Ke Xue.* 2009;29:191-195.
40. Wu YY, Ding L, Xia HL, Tu YY. Analysis of the major chemical compositions in fuzhuan brick-tea and its effect on activities of pancreatic enzymes in vitro. *Afr J Biotechnol.* 2010;9:6748-6754.
41. Yu Z-y. Research of the Anti-Diarrhea Function of Fuzhuan Tea.*Cha Ye Ke Xue.* 2009;29:465-469.
42. van Hylckama Vlieg JET, Veiga P, Zhang C, Derrien M, Zhao L. Impact of microbial transformation of food on health--from fermented foods to fermentation in the gastro-intestinal tract. *Curr Opin Biotechnol.* 2011;In Press, Corrected Proof.