Recent progress of the chemical constituents and biological activities of tea stems and tea hairs

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ABSTRACT

Tea is a traditional beverage that originated in China, the world's largest tea producer. However, during tea processing, a lot of tea stems and tea hairs are produced and usually discarded, which results in a large amount of waste. In this minireview, we mainly focused on reviewing the recent progress of chemical compositions and biological activities of tea stems and tea hairs by searching the CNKI, PubMed, Web of Science, Scopus, and Google Scholar databases using “tea hairs and tea stems” as the key words, to provide the good reference for the comprehensive development and utilization of tea stems and tea hairs.

Key words: Tea stems, tea hairs, chemical constituents, biological activities.

INTRODUCTION

Tea, the primary ingredient in many traditional beverages, has a long history in China. Tea is also the most popular natural beverage in the world, and tea, coffee and cocoa are said to be the three major beverages in the world.

In China, tea culture has developed over a long history and China has the largest tea production in the world. China’s tea culture spread across the globe from Quanzhou (in the Fujian Province of China), a thousand years ago, making China tea a global hit. Quanzhou is a famous cultural city and it is also the beginning of the "Silk Road of the Sea". Among them, Anxi county of Quanzhou is the hometown of oolong tea (a world-famous tea). Since ancient times, it has been referred to as the "Southern Fujian Tea Capital". Thus, with the rapid development of tea industry, Anxi has gradually amassed abundant tea varieties, and as a result, it was known as "the treasure house of fine tea varieties".

According to statistics, Quanzhou's tea plantations will cover 790,000 mu by 2019. The total area covered by mature tea trees is 784,100 mu, and 87,100 jin of raw tea are produced annually. In 2021, 93,900 tons of raw tea are produced. However, in the process of tea refining, a large number of by-products (such as tea stems, tea hairs) is produced. These by-products have not been developed and utilized, and are often discarded as wastes, causing waste of resources. In addition, the putrid tea stems and tea hairs also pollute the environment. Therefore, it is very important to explore the value of these discarded raw materials.

It has been reported that there are many active natural components (such as tea polyphenols, tea polysaccharides, theanine, caffeine, flavones, etc.). In this mini-review, the chemical components and biological activities of tea stems and tea hairs were comprehensively summarized by searching the CNKI, PubMed, Web of Science, Scopus, and Google Scholar databases using "tea hairs and tea stems" as the key words. The researcher may find this article helpful in their future work on tea stems and tea hairs. They should be thoroughly developed and used, particularly in food, drink, medicine, and other essentials.

THE CHEMICAL COMPOSITIONS

Tea polyphenols

The total polyphenols in tea are commonly referred to as tea polyphenols. The main components of tea polyphenols are flavanones, anthocyanins, flavonols and anthocyanins, phenolic acids and depsidic acids. Among them, flavanones
are the key components and account for 60 to 80% of the total tea polyphenols. Catechin can roughly be divided into epicatechin (EC), epicatechin Gallocatechin (EGC), epicatechin-3-gallate (ECG) and epigallocatechin-3-gallate (EGCG), etc. (Figure 1) (Chen et al., 2022). Tea polyphenols are easily soluble in water and organic solutions, and are the main active components of the tea. According to published data, tea polyphenols have antioxidant, antibacterial, anti-aging and other effects, and are widely used in food, medicine, cosmetics and other fields. Liu (2022) studied the extraction and separation technology of tea polyphenols. The extraction technologies of tea polyphenols include solvent extraction, supercritical fluid extraction, microwave-assisted extraction, ultrasonic extraction, etc., while the separation techniques include: ion precipitation, column chromatography, macroporous adsorption resin method, etc.

Tea polysaccharides

Tea polysaccharide is an acidic glycoprotein, which often combines with a large amount of mineral elements, and was referred to as tea polysaccharide complex. The main components of tea polysaccharides are monosaccharides and uronic acids (Weng et al., 2021). Tea polysaccharides are insoluble in high concentrations of ethanol, ethyl acetate and other organic solvents. It has poor thermal stability, and it will decompose at the high temperatures. Hu (2022) found that tea polysaccharide has anti-cancer, antioxidant, hypoglycemic, lipid-lowering effects. Tea polysaccharides are widely used in the adjuvant treatment of diabetes because of their highly effective hypoglycemic effect. The extraction techniques of tea polysaccharides include hot water extraction, enzymatic extraction, ultrasonic-assisted extraction, microwave-assisted extraction, boiling water extraction, etc, while the separation techniques of tea polysaccharides include gel chromatography, ion exchange chromatography, macroporous resin chromatography, etc (Cheng et al., 2021).

Theanine

Theanine (structure showed in Figure 2) is a peculiar non-protein amino acid of the tea, and it is abundant in the tea, which directly determines the flavor of the tea. Theanine is soluble in water but insoluble in ethanol and ether. Ji et al. (2022) reported that theanine has beneficial effects on human health, such as lowering blood pressure, protecting brain nerves, and improving immunity. In recent years, theanine (Yang, 2018; Zhang et al., 2003) has been mainly used in food and beverages, medicines and health care
products. The extraction techniques of theanine include: ion precipitation, ultrasonic-assisted extraction, microwave-assisted extraction, etc. Separation techniques (Ge, 2013) include: chromatographic separation, membrane separation, resin chromatography, etc.

**Caffeine**

Caffeine (structure showed in Figure 3) is a xanthine alkaloid (Yang et al., 2022). Caffeine is a central nervous system stimulant, it can relieve fatigue. It has positive effects such as refreshing, diuretic, and clinically used to treat neurasthenia and coma recovery. However, caffeine also has some side-effects: excessive intaking of caffeine can lead to insomnia, increased blood pressure, miscarriage, etc.

Therefore, the application of caffeine in food has been forbidden. But it has been shown that theanine can antagonize caffeine and inhibit the excitation of the nervous system caused by caffeine, so that it can reduce the neurological side effects caused by caffeine (Yu et al., 2012; Li et al., 2019). Xie and Lin (2022) reported that caffeine can be used to treat the apnea-related gene polymorphisms in premature infants. The extraction processes of tea include solvent extraction method, ionic liquid extraction method, ultrasonic-assisted method and microwave-assisted method, etc. Separation methods include thin layer chromatography, paper chromatography, etc (Wang et al., 2020).

**THE PROGRESS OF BIOLOGICAL ACTIVITIES**

**Antioxidant**

The chemical components with antioxidant properties in tea stems and tea hairs are tea polyphenols, tea polysaccharides, etc. Studies found that although tea polysaccharides have antioxidant properties, the antioxidant properties of tea polysaccharides are lower than that of tea polyphenols. Therefore, the main components of antioxidant activity in tea stems and tea hairs are tea polyphenols.

Chen (2021) found that the chemical extract in the tea stem has a color-protecting effect on fresh-cut apples to prevent their oxidative discoloration from producing carcinogens, and it has no toxic effect on human body. Jiang et al. (1999) found that tea polyphenols can significantly inhibit the hemolysis of human red blood cells caused by ultraviolet rays. Wang et al. (2015) found that tea polysaccharides in Pu-er can inhibit replicative aging in humans, which may delay cell aging by protecting the mitochondria of aging HDP cells from oxidation. Lin et al. (2015) found that the scavenging rate of the polysaccharide of Baihao Yinzhen tea hairs at a concentration of 0.22 mg/mL against $\cdot$OH was 38.40%, and the scavenging rate of $\cdot$OH was dose dependent with the concentration of tea polysaccharide.

**Prevent and treat diabetes**

Diabetes is a common metabolic disorder today. It produces
a variety of concurrent symptoms, and it causes a huge threat to human health. Therefore, prevention and treatment of diabetes is very important for the orders. Studies have shown that the main chemical components in the extracts of tea stems and tea hairs regulated blood sugar level are tea polysaccharides and theanine. Yang et al. (2018) found that tea polysaccharides can reduce blood sugar and prevent diabetes by protecting pancreatic β cells, inhibiting the absorption of exogenous carbohydrates, and controlling glucose metabolism enzymes and insulin in the body. Yu et al. (2012) showed that the polysaccharide extracted from Anji white tea can significantly reduce the blood sugar of the norepinephrine-induced diabetic mice caused by alloxan injection, and the polysaccharide did not affect the glucose tolerance and blood sugar of the testing mice themselves. What’s the most important is that the blood sugar-lowering effect of Anji white tea polysaccharide group was equal to the drug’s group. Li et al. (2012) found that L-theanine could prevent diabetes by enhancing superoxide dismutase activity and inhibiting lipid peroxidation to regulate free radicals. Wan et al. (2014) found that the L-theanine-zinc complex has a significant effect on inhibiting diabetes by lowering blood sugar.

**Anti-tumor, anti-cancer**

It was found that the chemical components (tea polyphenols, tea polysaccharides, theanine, etc.) can be used to prevent tumors. Li et al. (2002) found that tea polyphenols had the preventive effects on tumors and cancers by inhibiting mutation stage, regulating the growth of somatic cells, inhibiting the growth of cancer cells, inhibiting the metastasis of cancer cells, etc. Hu et al. (2000) found that tea polyphenols can inhibit skin tumors caused by ultraviolet rays mutating the skin. Cao and Shao (1999) studied that in vivo antitumor activity of tea polyphenol complexes and the results showed that tea polyphenols could cause tumor cell apoptosis by preventing tumor cell growth during the process. Yuan et al. (2018) found that tea polysaccharides had antitumor effects by promoting the immune cells. Wei et al. (2016) found that tea polysaccharide had synergistic effect with doxorubicin, thereby enhancing the effect of doxorubicin on inhibiting tumor and cancer cells, and reducing the side effects of doxorubicin. It has been reported that although theanine could not directly inhibit the cancer cell lines, it can enhance the effect of anti-cancer drugs by inhibiting the infiltration of cancer cells to prevent the spread of cancer cells, and reduce the side effects of drugs (Zheng, 2019; Gao et al., 2010).

**Anti-inflammatory**

Inflammation is very common, and it can cause many related diseases. Therefore, we should pay attention to its impact on the human body. It has been confirmed that tea has a significant effect on anti-inflammatory by regulating various inflammatory factors. Many chemical components of tea (such as tea polysaccharides, theanine, etc.) have anti-inflammatory activity, while tea polyphenols are more potent than other components. Zhao et al. (2021) studied the anti-inflammatory mechanism of tea polyphenols and found that tea polyphenols could effectively promote the proliferation of fibroblasts, promote the production of collagen, inhibit the reproduction of wound bacteria, etc., thereby inhibiting the occurrence of infectious inflammation in wounds. Xu et al. (2020) found that tea polyphenols could reduce the content of pro-inflammatory factors in the liver, thereby reducing the acute liver injury induced by lipopolysaccharide. Xu et al. (2021) found that tea polysaccharides could reduce colon inflammation by feeding tea polysaccharides to mice suffering from ulcerative colitis induced by dextran sulfate sodium. Gao (2019) found that theanine could reduce the inflammation and acute liver injury caused by lipopolysaccharide. Shibakusa et al. (2012) found that oral theanine for the surgical mice could inhibit the increase of inflammatory cytokines in blood.

**Antibacterial**

In daily life, bacteria are everywhere, and bacteria are invisible to our naked eyes. Some of them are both useful, while some of them are harmful to our life. Just like the probiotics in yogurt, it can help the bowel to move and aid digestion. However, some bacteria (such as Staphylococcus aureus and Escherichia coli) will become pathogens and cause harm to human beings (Zeng, 2020). It has been found that tea polyphenols, tea polysaccharides, theanine, etc. can inhibit the growth of bacteria, and the bacteriostatic agents composed by these components are very efficient and environmentally friendly. Li et al. (2021) developed an effective natural fruit compound preservative containing tea polyphenols, which can inhibit the growth of Escherichia coli, Bacillus subtilis and Staphylococcus aureus. Diao (2018) prepared liquid soap containing tea extract and found that the liquid soap had better antibacterial activities than the soap on the market. Song et al. (2021) found that Meitan white tea polysaccharides had good in vitro antibacterial activity and stability. In a study, Wang et al. (2006) reported that tea polyphenols and theanine had a certain inhibitory effect on Escherichia coli and Staphylococcus aureus.

**Conclusion**

As a natural health drink, tea is increasingly valued. However, during the processing of tea, much tea stems and
tea hairs are produced and usually discarded, which results in a large amount of waste. While people pay more and more attention to green environmental protection, the chemical components in tea stems and tea hairs have been developed and used in the fields of beverages, cosmetics, medicines and health products.

Our group has taken the lead to study the tea hairs and tea stems, and obtained good results (Xiao et al., 2021; Yong et al., 2021; Xie et al., 2021; Wang et al., 2022). However, in order to promote its development and utilization, much research should be carried out based on the following aspects: (1) further research on the isolation of their chemical components, biological activities should be carried out; (2) the residues of extracted tea stems and tea hairs can be explore for biomass carbon materials. This review article provides the good reference for the researchers.

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REFERENCES

Chen ZJ (2021). Color protection of fresh cut apple by extract from tea stem. J. Wuji University 40(9):6-10.

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