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Review

Recent advances in tea polysaccharides: Extraction, purification, physicochemical characterization and bioactivities

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ABSTRACT

Tea has a long history of medicinal and dietary use. Tea polysaccharide (TPS) is regarded as one of the main bioactive constituents of tea and is beneficial for health. Over the last decades, considerable efforts have been devoted to the studies on TPS: extraction, structural feature and bioactivity of TPS. However, it has been received much less attention compared with tea polyphenols. In order to provide new insight for further development of TPS in functional foods, in present review we summarize the recent literature, update the information and put forward future perspectives on TPS covering its extraction, purification, quantitative determination techniques as well as physicochemical characterization and bioactivities.

Contents

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1. Introduction

Tea, made from the leaves and buds of tea plant (*Camellia sinensis* L.), has a long history of over 5000 years in dietary and medicinal applications especially in Asian countries including China, Japan, India and Thailand (Cao, 2013; Yang et al., 2010). Nowadays, tea becomes more and more popular due to its alleged health-promoting effects such as antioxidant, anticancer, antiinflammatory, immunomodulatory, hypoglycemic and chemopreventive activities (Granato, Grevink, Zielinski, Nunes, & van Ruth, 2014). Next only to water, tea has been one of the most popular beverages consumed in the world, well ahead of carbonated soft drinks, wine, beer and coffee (Cai, Xie, Chen, & Zhang, 2013). The chemical constituents of tea mainly include polysaccharides, polyphenols, alkaloids, amino acids, proteins, organic acids and volatile compounds (Chen, Wang, Lu, & Xie, 2008; Xiao, Huo, Jiang, & Yang, 2011). Most researchers concentrated on low molecular weight components in tea such as theanine, caffeine and catechins, therefore, in the past few decades great advances have been made in understanding the physicochemical characterization and bioactivities of catechins and polyphenols from teas. However, tea polysaccharides (TPS) have been received much less attention than tea catechins and polyphenols (Wang, Zhao, Andrae-Marobela, Okatch, & Xiao, 2013).

It is well known that coarse tea leaves has traditionally been used for treatment of diabetes, particularly in China, Korea and Japan (Jin, Jia, & Tu, 2015; Yang, Chen, & Gu, 2012). It has been reported that the content of polyphenols in coarse tea leaves is low, and TPS is one of the main bioactive components in coarse tea (Chen, Zhang, & Xie, 2005; Wang, Wang, Li, & Zhao, 2001). Since the mid of the 20th century, polysaccharides as biological response modifiers have been received more and more attention by nutritional and biochemical scientists duo to their various biological functions (Sun, 2011b). Furthermore, polysaccharides have been reported to be non-toxic with very least side-effects and could be potentially used in pharmaceutical, food and cosmetic industries (Chen, Zhang, Qu, & Xie, 2007; Shashidhar, Giridhar, & Manohar, 2015). In recent decades, much attention has also been focused on TPS and great advances have been made in the physicochemical characterization and bioactivities of TPS (Chen, Zhang, & Xie, 2004; Jin, He, Jia, & Tu, 2015; Xiao & Jiang, 2015). Especially, the structure of TPS and the possible mechanisms of bioactivity have become hot research in past two years. Apart from anti-diabetic activity, TPS has been shown a variety of other characteristics, such as antioxidant, antitumour, hepatoprotective, immunostimulating and antiviral activities (Cao, 2013; Nie & Xie, 2011). Due to its various bioactivities, TPS has great potential applications as natural products in functional foods. Therefore, the aim of the present review is to compare and summarize previous and current research works regarding the extraction, purification, quantitative determination techniques as well as physicochemical characterization and bioactivities of polysaccharides from tea leaves, seeds and flowers.

2. Classification basis of tea

Tender shoots, such as one or two leaves and a bud, are usually used in the making of green and black teas, whereas coarse tea leaves (mature tea plant shoots) are usually used to produce dark tea (Wang, Wang, Li et al., 2001). Generally, the tender shoots of tea leaves have higher contents of polyphenols, caffeine and catechins than coarse tea leaves (Xiao & Jiang, 2015). In contrast, Wang, Wang, Li et al. (2001) found that the content of TPS in coarse tea leaves was higher than that of tender shoots. Depending on the manufacturing process, teas are usually classified into 6 categories in China: unfermented (green tea), slight-fermented (white tea and yellow tea), semi-fermented (Oolong tea), fermented (black tea) and post-fermented (dark tea) teas (Tanaka et al., 2012; Zhao, Huangfu, Dong, & Liu, 2014). To clearly understand the differences between various teas, the manufacturing processes of teas are profiled as shown in Fig. 1. Green tea, claimed to be the second most consumed beverage in the world, is heated and dried to avoid enzymatic oxidation of catechins. Yellow tea presents a similar processing conditions as green tea, however, process of enzyme inactivation in yellow tea is at a slower rate to allow the fresh tea leaves to become yellow with the help of oxidizing enzymes (Granato et al., 2014; Hashimoto et al., 2007; Peng et al., 2016). White tea, different from the other types of tea due to its white leaf hairs on the surface of tea, is withered after harvest of the fresh tea leaves and dried immediately to prevent enzymatic oxidation of catechins and to have a delicate taste (Rusak, Komes, Likić, Horžić, & Kovač, 2008). Oolong tea, which is widely consumed in Asia for health benefit with a color and taste between black tea and green tea, is semi-fermented to permit a lower level of enzymatic oxidation of catechins than black tea during the process (Rusak et al., 2008; Wang, Shao et al., 2012).

Black tea is a type of tea that the catechins in fresh tea leaves are most thoroughly oxidized by polyphenol oxidases and peroxidases during the process (Granato et al., 2014; Zhu, Hackman, Ensunsa, Holt, & Keen, 2002). In contrast, dark tea is post-fermented tea produced by aerobic or anaerobic microbial fermentation of heat-processed green tea leaves (Tanaka et al., 2012; Zhang, Zhang, Zhou, Ling, & Wan, 2013). Thus, the degree of fermentation is defined as follows: black tea or dark tea > Oolong tea > yellow tea or white tea > green tea (Hashimoto et al., 2007). The polysaccharide contents, physicochemical properties and bioactivities of TPS are closely related to the origin of tea (Chen, Qu, Fu, Dong, & Zhang, 2009; Scoparo et al., 2013). Apart from tea leaves, tea flowers and seeds are also main sources of TPS (Wang, Mao, & Wei, 2012; Wang, Yu, Zhang, Xiao, & Wei, 2010; Wang, Chen et al., 2013; Wei, Chen et al., 2010; Wei, Mao, Cai, & Wang, 2011).

3. Extraction, isolation and purification of tea polysaccharides

3.1. Extraction of crude polysaccharides

Tea leaves, flowers and seeds are three main sources of TPS and many works have been reported on the extraction of TPS. Most bioactive polysaccharides are polar in nature, therefore polar solvents, such as hot water and hot alkali solution, are used to extract polysaccharides (Shashidhar et al., 2015). Extraction with hot water, as a classical method, has been widely applied in food and medicine industry for preparation of polysaccharides (Jin, Zhao, Huang, Xu, & Shang, 2012). Xu, Wu, Zhang, Chen, and Wang (2014) prepared TPS by extracting 3 times from Pu-erh tea with hot water at 70 °C for 60 min. Three kinds of crude TPS were obtained from black, Oolong and green teas with hot water at 70 °C for 60 min and 3 times, respectively (Chen, Qu et al., 2009). Also, Wang, Li, Liu, Chen, and Wei (2015b) prepared Se-enriched TPS by extracting twice with distilled water. Jin, He et al. (2015) used response surface