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Green tea extract: Chemistry, antioxidant properties and food applications – A review

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ABSTRACT

Green tea is one of the most popular and extensively used dietary supplement in the United States. Diverse health claims have made for green tea as a trendy ingredient in the growing market for nutraceuticals and functional foods. Green tea extract contains several polyphenolic components with antioxidant properties, but the predominant active components are the flavanol monomers known as catechins, where epigallocatechin-3-gallate and epicatechin-3-gallate are the most effective antioxidant compounds. Additional active components of green tea extract include the other catechins such as epicatechin and epigallocatechin. Among these, epigallocatechin-3-gallate is the most bioactive and the most scrutinized one. Green tea polyphenols are also responsible for distinctive aroma, color and taste. Green tea extract can also be used in lipid-bearing foods to delay lipid oxidation and to enhance the shelf-life of various food products. This review outlines the chemistry, flavour components, antioxidant mechanism, regulatory status, food applications, and stability of green tea extract in food.

Contents

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1. Introduction

Tea, derived from *Camellia sinensis* L., is one of the most widely consumed beverages in the world. Tea can be categorized into three main types, depending on the level of oxidation, as green tea, oolong tea and black tea (Chan, Soh, Tie, & Law, 2011; Velayutham, Babu, & Liu, 2008). Green tea is an evergreen plant that grows primarily in tropical and temperate regions of Asia which mainly include China, India, Sri Lanka and Japan. It is also cultivated in several African and South-American countries. Two primary varieties of *C. sinensis* are *Camellia sinensis sinensis* and *Camellia sinensis assamica*. The *sinensis* plant strain is originated from China. This strain produces green, white, black and oolong teas. On the contrary, the *assamica* plant strain primarily is inhabitant to the Assam region in Northern India. Due to enormous yields of this specific strain, it is the favored plant grown in India, Sri Lanka and some African countries. The leaves of *assamica* strain are typically used for producing black, oolong and pu'erh teas. Green tea is a small shrub that can expand up to 30 feet high, but is customarily trimmed to 2–5 feet when cultivated for its leaves. The leaves are naturally murky green and glossy with notched edges and are 2–5 cm broad and 4–15 cm long. The flowers are white and contain bright yellow stamens. These blossoms appear individually or as clusters. The fruits have hard green shells with round, brown-colored seeds. These seeds can be used to produce tea oil. Typically, flowering is prevented during cultivation by harvesting the leaves. The immature, light-green leaves are preferably harvested for tea production. Mature leaves are deeper green in color than the young leaves. Different leaf ages produce varying tea qualities as their chemical compositions are different. Typically, the buds (tips) and the first two to three leaves are harvested by hand picking for processing. This process is generally repeated every one to two weeks. Green, white, black and oolong teas all originate from the leaves of *C. sinensis* plant. However, the different types of tea are classified according to the degree of fermentation that takes place during processing: both white tea and green tea being unfermented; oolong tea semi-fermented and black tea fully fermented (Chan et al., 2011). These basic types of tea have different quality characteristics, including appearance, aroma, taste, and color. The manufacturing process of tea is designed to either preclude, or permit tea polyphenolic compounds to be oxidized by naturally occurring polyphenol oxidase in the tea leaves. Green tea is produced by inactivating the heat-labile enzyme polyphenol oxidase in the fresh leaves by either applying heat or steam, which prevents the enzymatic oxidation of catechins, the most abundant flavonoid compounds present in green tea extracts (Velayutham et al., 2008). The tea leaves are then rolled, dried and packaged.

2. Chemistry

The chemical composition of tea leaves has been well documented. The main constituents of tea leaves are polyphenols (Balentine, Wiseman, & Bouwens, 1997). The fresh tea leaves contain caffeine (approximately 3.5% of the total dry weight), theobromine (0.15–0.2%), theophylline (0.02–0.04%) and other methylxanthines, lignin (6.5%), organic acids (1.5%), chlorophyll (0.5%) and other pigments, theanine (4%) and free amino acids (1–5.5%), and numerous flavour compounds (Graham, 1992). In addition, a wide variety of other components exists, including, flavones, phenolic acids and depsides, carbohydrates, alkaloids, minerals, vitamins and enzymes (Chaturvedula & Prakash, 2011). Tea also contains flavonols, mainly quercetin, kaempferol, myricetin, and their glycosides. The most favorable effects of green tea are accredited to the green tea polyphenols, predominantly the catechins, which make up, 25–35% of the dry weight of green tea leaves (Abdel-Rahman et al., 2011; Balentine et al., 1997; Graham, 1992; Zaveri, 2006). The tea catechins belong to the family of flavonoids (Yilmaz, 2006) and possess two benzene rings referred to as the A- and B-rings. In addition, the catechin molecules contain a dihydropyran heterocycle (the C-ring) that has a hydroxyl group on carbon 3. Moreover, the A-ring is similar to a resorcinol moiety whereas the B-ring is similar to a catechol moiety. The catechin molecule has two chiral centers on carbons 2 and 3. Hence, it has four diastereoisomers with two of the isomers are in *trans* configuration, and the other two are in *cis* configuration. The *trans* and *cis* isomers are referred to as the catechin and epicatechin, respectively. These chemical structures appear to be important for the antioxidant activities of tea polyphenols, including an *ortho*-3′4′-dihydroxyl group or 3′4′5′-trihydroxyl group in the B-ring, a gallate group located at the 3 position of the C-ring, and hydroxyl groups at the 5 and 7 positions of the A-ring (Rice-Evans, Miller, & Paganga, 1996). Many structure–activity relationship investigations have been performed on the antioxidant activity of flavonoids, including tea catechins (Farkas, Jakus, & Héberger, 2004; Guo et al., 1999; Harborne & Williams, 2000; Heim, Tagliaferro, & Bobilya, 2002; Rice-Evans et al., 1996). According to these studies, the antioxidant activity of flavonoids depends substantially on the number and position of hydroxyl groups in the molecule (Farkas et al., 2004). In addition, several structural elements such as o-dihydroxyl catechol structure in the B-ring, the presence of unsaturation and 4-oxo group in the C-ring are also presumed to increase the antioxidant activity of flavonoids. The 2,3-double bond in the C-ring along with 4-oxo function in the C-ring facilitates electron delocalization from the B-ring. Moreover, hydroxyl groups at positions 3 and 5 providing hydrogen bonding to the 4-oxo group in the C-ring is another structural feature attributed to the antioxidant activity of flavonoids.