Applications of tea extract for inhibiting lipid oxidation in food products

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Abstract

Tea (*Camellia sinensis* L.) is widely consumed in the world. Especially, green tea is widely consumed in East Asia countries due to health benefits included chloresterol reduction, anticancer, antitumor and antioxidant. Catechins derivatives i.e. epigallocatechin-3-gallate (EGCG), epigallocatechin (EGC), epicatechin (EC) and epicatechin-3-gallate (ECG) are the major and important bioactive compounds in green tea besides of other polyphenols. They are powerful antioxidants and able to delay rancidity in food products by both directly fill into food products and incorporate in anti-oxidative film. Tea extracts are chosen to use as natural antioxidants instead of synthetic antioxidants i.e. butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) and tert-butylhydroquinone (TBHQ). This review outlines the kinetic of lipid oxidation and the application of tea extract to inhibit lipid oxidation in food products.

Keywords: tea (*Camellia sinensis* L) extract, lipid oxidation, antioxidant

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Introduction

Tea is one of the most popular drinks in the world and has been used for centuries for its medicinal properties. Green tea, oolong tea and black tea are extensively recognized among consumers. Black tea is commonly consumed in western countries, meanwhile green tea have been popular among Asian countries because of their benefits namely antioxidant, antibacterial and anticancer properties (Lu et al., 2010). Tea be consumed in forms of brewing loose leaves, dipping tea bags, as well as ready-to-drink (Wang et.al, 2003). Tea extract, i.e. primarily referring as extracts of green tea, is an interesting product having high antioxidant activity of its high polyphenol content. This review purposely investigates the applications of tea extract in food products, with an emphasis on inhibiting lipid oxidation and extending shelf life of food products.

1.Tea extract

Although synthetic antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) and tert-butylhydroquinone (TBHQ) are widely used in food processing to control oxidation and maintain quality of food products; for example, chicken burger (Periera et al., 2017), precooked pork patties (Jieng et al., 2013) and beef patties (Vargas-Sanchez et al., 2014) but there are concerns on their effects on health due to their carcinogenic properties (Sarah et al., 2010).Alternatively natural antioxidants derives from plants such as plant extracts are becoming interestingly because they are typically less harmful than synthetic ones and have equivalent effect upon the inhibition of oxidation (Barry-Ryan et al., 2008). Furthermore, it has continuously become awared attributed to the fact that free radicals such as reactive oxygen species (ROS) which responsible for various diseases including cardiovascular disease, arteriosclerosis, cancer and aging related disoders (Abu-Salem et al., 2011). Tea extract, especially green tea extract (GTE), is one of the most popular plant extracts that has been used in various food and beverage applications. There are many types of tea extract such as strong infusion (by soaking tea leaves in alcohol and water mixtures, the catechins content is about 2% w/v), soft extract (by concentrating the strong infusion to a water content of 20-25 %, the catechins content is about 20% w/w), and dry extract (by spray drying the strong infusion after they have been concentrated to 40-50 % solids; the catechins content is about 25% w/w) (Wang et.al, 2003). Tea extract is a very good source for polyphenols including flavonoids and catechins that have the potential antioxidant property (Kumudavally et al., 2008). Besides of the health benefits of natural antioxidants, it also prevents the lipid oxidation and prevents the loss of food quality and sensory attribute. Therefore, it is advantage for extending the shelf life of food (Perumallaa and Hettiarachchy, 2011).

2. Applications of tea extract to delay lipid oxidation.

Lipid oxidation in food products is considered as one of the main factor limiting product quality and acceptability due to the production of ROS and off-flavors from unsaturated fatty acid. It is a major cause of food deterioration that occurs the off-flavor and unpleasant odors. This reaction may be stimulated by light and O_2. GTE is used for inhibiting and retarding lipid oxidation due to its antioxidant activity (Sarah et al., 2010). The mechanism of lipid oxidation can be discussed in three steps including initiation, propagation and termination (Figure 1) (Perumallaa and

Hettiarachchy, 2011). Free radicals such as peroxyl radical ($ROO^{\bullet}$) are produced at initiation step and reacted with unsaturated fatty acid to form lipid hydroperoxide (ROOH) that continue to form the off-flavor that cause the deterioration in food products. The addition of antioxidant from natural, especially GTE is one of the strategies to retard lipid oxidation. (Sarah et al., 2010).

Initiation step: unsaturated fatty acid (RH) reacted with oxygen (O_2) in presence of light to form peroxyl radicals ($ROO^{\bullet}$) resulting the loss of hydrogen radical ($H^{\bullet}$).

$$RH \longrightarrow R^{\bullet} + H^{\bullet}$$

$$R^{\bullet} + O_2 \longrightarrow ROO^{\bullet}$$

Figure 1 The mechanism of lipid oxidation.

Source: Perumallaa and Hettiarachchy. (2011)

Propagation step: peroxyl radicals ($ROO^{\bullet}$) react with more unsaturated fatty acids to form hydroperoxide (ROOH).

$$ROO^{\bullet} + RH \longrightarrow ROOH + R^{\bullet}$$

Termination step: peroxyl radicals ($ROO^{\bullet}$) react to produce a non-radical species (ROOR or RR).

$$ROO^{\bullet} + ROO^{\bullet} \longrightarrow ROOR + O_2$$

$$ROO^{\bullet} + R^{\bullet} \longrightarrow ROOR$$

$$R^{\bullet} + R^{\bullet} \longrightarrow RR$$

Figure 1 The mechanism of lipid oxidation (continued).

Source: Perumallaa and Hettiarachchy. (2011)

Antioxidant activity (AH) refers to delay lipid oxidation by inhibiting the initiation and propagation step of oxidative chain reaction and forming stable radical (A·) which are either unreactive or form non-radical products (Figure 2) (Perumallaa and Hettiarachchy, 2011).

$$ROO^{\bullet} + AH \longrightarrow ROOH + A^{\bullet}$$

Figure 2 Mechanism of antioxidant to free radical for inhibiting lipid oxidation.

Source: Perumallaa and Hettiarachchy. (2011)

From figure 2, antioxidant including phenolic compound (mainly flavonoids) present in GTE have demonstrated potential antioxidant property by interrupt the propagation of free radical oxidation chain by contributing a hydrogen atom from a phenolic hydroxyl group with the formation of a relatively stable free radical ($A^{\bullet}$). This stable free radical does not initiate and propagate further oxidation process (Barry-Ryan et al., 2008). Therefore, flavonoids can act as free radical scavenger (Turkoglu et al., 2007).

Lu et al. (2010) reported that the replacement of wheat flour with green tea powder for making sponge cake led to increase the catechins content, antioxidant activity and scavenging ability on DPPH radicals. Sponge cake was made by using green tea powder substituted to 10-30% of wheat flour and without green tea powder (control) and packed in polypropylene bags at room temperature. The results showed that the antioxidant activity and scavenging ability on DPPH radicals of the sponge cake having green tea powder were greater than those of the control (Table 1)

Table 1 Catechins content, antioxidant activity and scavenging ability on DPPH radicals of sponge cake with green tea powder substituted to 10, 20 and 30 % of wheat flour i.e. designated as GT10, GT20 and GT30, respectively.

Property	Control	GT10	GT20	GT30
Catechins (mg/100g sponge cake)	-[c]	6.86 ± 0.11 [b]C	13.12 ± 0.15 B	20.38 ± 0.30 A
Antioxidant activity EC_{50} values [a]	14.83 ± 0.79A	13.45 ± 0.47 B	11.12 ± 0.51 C	8.89 ± 0.69 D
Scavenging ability on DPPH radicalsEC_{50} values	31.81 ± 4.26 A	12.86 ± 0.59 B	0.11 ± 0.01 C	< 0.01 C

[a]The lower EC_{50} values indicated the higher antioxidant activity.

[b] Mean ± standard deviation. Values with different capital letter within a row are significantly different ($P < 0.05$).

[c] -, not detected.

Source: Modified from Lu et al. (2010)

From Table 1, the addition of green tea powder instead of wheat flour affected the increasing of catechins content that resulting to increase antioxidant activity of sponge cake. Therefore, it is suitable for consumer for receiving the high antioxidants through bakery products besides of fruits and vegetables.

Tang et al. (2006) demonstrated tea catechins had an antioxidant potential to inhibit lipid oxidation in fresh minced beef patties compare to control during storage at 4 °C for 7 days. Furthermore, Dicastillo et al. (2011) studied the ethylene vinyl alcohol copolymer (EVOH) containing GTE for reducing oxidation reaction and food deterioration. This film was placed in aluminum/ LDPE bag with vacuum packaging stored at ambient temperature (23 ± 2°C). It was tested with 95 % v/v ethanol as fatty food simulant, 3 % v/v acetic acid as acidic food simulant, 10%v/v ethanol as alcoholic food simulant and water as the aqueous food. The result showed that the copolymer films greatly affected to the 95 % v/v ethanol as fatty food simulant due to the antioxidant activity of GTE contained in film. Furthermore, Rababah et al. (2006) reported that GTE decreased lipid oxidation of the raw chicken breast meat during storing at 5 °C for 6 and 12 days. GTE affected to the decreasing of TBARS value (Table 2). Hexanal that was the main volatile compound from lipid oxidation in raw chicken breast meat treated with GTE were 1,743.8 and 1,816.3 ppb during storage at 6 and 12 days was lower than control. The increasing of hexanal in control could be due to an increase of lipid oxidation. Therefore GTE demonstrated an antioxidant potential due to its phenolic compound that could decrease lipid oxidation by inhibiting the formation of free radicals during the initiation step or interrupting of the propagation of free radical chain reaction by acting as an electron doner (Nawar, 1998)

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Table 2 TBARS value (mg of malondialdehyde / kg of raw chicken breast meat) and hexanal content (ppb) of raw chicken breast meat treated with GTE compared to control and stored at 5 °C for 6 and 12 days.

Treatment	Control	Green tea extract
TBARS value		
6 days	42.4 a	19.8 b
12 days	67.8 a	38.0 b
Hexanal		
6 days	2,767.9 a	1,743.8 b
12 days	2,879.7 a	1,816.3 b

a-b Values within a row with different letter are significantly different (P < 0.05).

Source: Modified from Rababah et al. (2006)

From table 2, lower TBARS value of raw chicken breast meat treated with GTE was observed during storage at 6 and 12 days which are 19.8 and 38.0, respectively, compared to control that were 42.4 and 67.8, respectively. Because the unstable hydroperoxide is formed during lipid oxidation and decomposes readily to shorter chain hydrocarbon such as aldehyde, which can be detected as TBARS (Benjakul et al., 2005b). Moreover, the application of tea extract in other food products were tench fillet (Gai et al 2014), pork patties (Shah et al., 2014), Pacific white shrimp (Nirmal and Benjakul, 2011), rice bran oil and breakfast cereal (Utama-ang et al., 2017). In addition, tea extract especially green tea extract could incorporate in anti-oxidative film to inhibit lipid oxidation of food containing fat products i.e. pork meat (Yang et al., 2016) and brine sardines (Dicastello et al., 2012).

Conclusion

Tea extract are effective to inhibit lipid oxidation by incorporated in anti-oxidative film and directly filled into food products. Catechins derivatives are strong antioxidants and main bioactive compounds inhibit lipid oxidation. Therefore, tea extract is good choice of natural antioxidant to use in food products for extending their shelf life. Beside of tea extract, it is interesting to investigate and apply the extract from *Polygonum odoratum* Lour. which contain high polyphenols and antioxidant activity by incorporate in anti-oxidative film for inhibiting lipid oxidation of food products.

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Reference

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