Possible mechanisms for antioxidant activity of added tea catechins in chicken muscle systems

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Background

Tea is one of the cheapest and most popular non-alcoholic beverages worldwide. Green tea has received considerable attention for its specific health claims and antioxidant properties because of the presence of functional polyphenols called tea catechins (TC). The principal catechins present in green tea are (-)-epicatechins (EC), (-)-epigallocatechin (EGC), (-)-epicatechin gallate (ECG) and (-)-epigallocatechin gallate (EGCG) (Graham, 1992). TC, in particular EGCG and ECG have been shown to exert potent inhibitory effects against oxidation of low-density lipoprotein *in vitro* (Miura *et al.*, 2000). Added TC have been reported to be effective antioxidants in pork (Shahidi *et al.*, 1992; Mc Carthy *et al.*, 2001). Dietary TC have been reported to improve oxidative stability in fresh and long-term frozen stored chicken meat (Tang *et al.*, 2000; 2001). However, there have been no published reports available on how TC exert their apparent antioxidant activities in chicken meat systems.

Objective

The objective of this study was to determine possible mechanisms responsible for the antioxidative activity of added TC in commercial chicken meat systems.

Methods

Fresh chicken breast and thigh meat were purchased from a local market. Meat was trimmed to remove bones, skin and visible fat, cut into 2.5 cm^3 pieces and minced through a 4 mm plate (Mainca mincer, Maquinaria Industrial, Carnica, Barcelona, Spain). Minced breast and thigh meat were each treated with 300 mg TC kg^{-1} (TC300). The TC used were extracted from green tea and contained 40% of EGCG, 24% of EGC, 12% ECG and 10% of EC. Meat without added TC was used as control (C). The treated samples were again minced through a 4 mm plate. Patties (30 g) were formed using a conventional burger-maker and overwrapped with oxygen-permeable clingfilm (6000-8000 cm^3 m^{-2} 24 h^{-1} at STP). Samples were displayed in a refrigerated (4°C) cabinet under fluorescent light (616 lux) for 10 days. Oxidative stability (TBARS) was measured at 3-day intervals using the method of Tarladgis *et al.* (1960).

The chelating activity of TC on Fe^{2+} was measured using the method of Decker and Welch (1990) and the free radical scavenging activity of TC was measured with 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical using the method of Yen and Wu (1999). All data were subjected to analysis of variance (ANOVA). The statistical significance of differences between mean values was analyzed by repeated measures and by Tukey's test in the general linear model using the SPSS statistical package.

Results and discussion

The influence of added TC on the oxidative stability of commercial chicken breast and thigh meat under retail conditions (4°C × 616 lux) for 10 days is presented in Fig. 1. Control thigh meat (C-T) had TBARS numbers above 2.0 mg malondialdehyde (MDA) kg^{-1} sample by day 2, whereas control breast meat (C-B) did not reach this value until day 10. Thigh meat is more susceptible to lipid oxidation than breast meat. TC added at a level of 300 mg kg^{-1} to both breast (TC300-B) and thigh (TC300-T) meat reduced TBARS numbers significantly ($p<0.001$) compared to controls. TBARS numbers in the TC-treated samples remained below 1.0 mg MDA kg^{-1} sample throughout the entire retail display period. This result was in agreement with our previous reports on antioxidant activity of dietary TC in chicken muscle (Tang *et al.*, 2000; 2001). Shahidi *et al.* (1992) reported strong TC antioxidant activity in a pig meat model system. Mc Carthy *et al.* (2001) reported that TC were the most effective antioxidants compared to rosemary, sage, fenugreek, ginseng and mustard for pork patties prepared from both fresh and previously frozen meat.

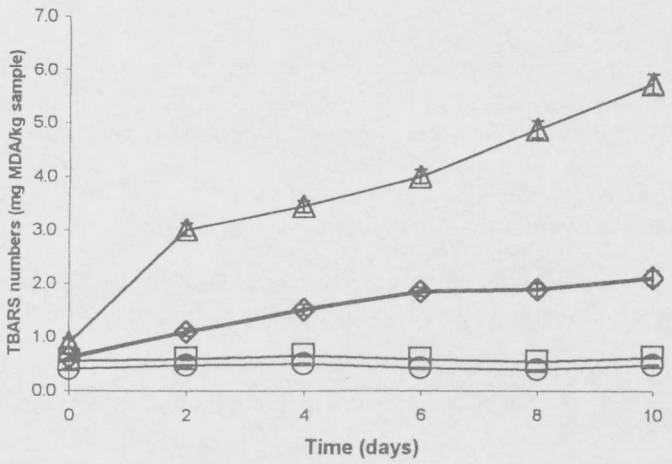

Fig. 1. Effects of added tea catechins on oxidative stability of fresh minced chicken meat stored in retail display at 4°C × 616 lux. △, thigh meat without addition of tea catechins (C-T); □, tea catechins at a level of 300 mg kg^{-1} minced thigh meat (TC300-T); ◇, breast meat without addition of tea catechins (C-B); ○, tea catechins at a level of 300 mg kg^{-1} minced breast meat (TC300-B). TBARS numbers are the mean values ± SEM (n=4) in the unit of mg malondialdehyde (MDA) kg^{-1} sample.

The free radical scavenging and iron chelating effects of TC are presented in Figs. 2 and 3, respectively. Commercial TC

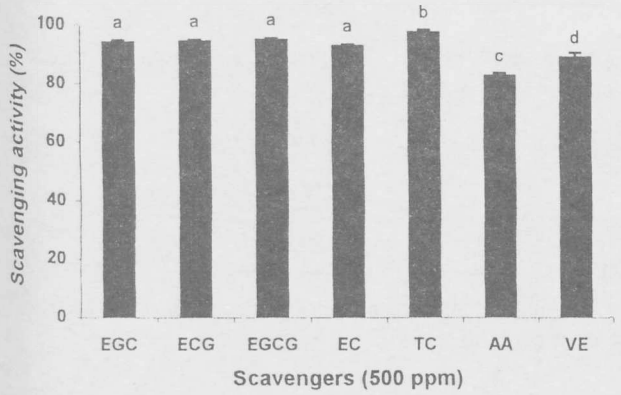

Fig. 2. Effects of tea catechins at 500 ppm on scavenging DPPH free radical. EGC, (-)-epigallocatechin; ECG, (-)-epicatechin gallate; EGCG, (-)-epigallocatechin gallate; EC, (-)-epicatechin; TC, commercial TC extract (86% purity); AA, L-ascorbic acid; VE, α-tocopherol. Values = means ± SEM (n = 4). Error bars with the different letters are significantly at $p<0.05$.

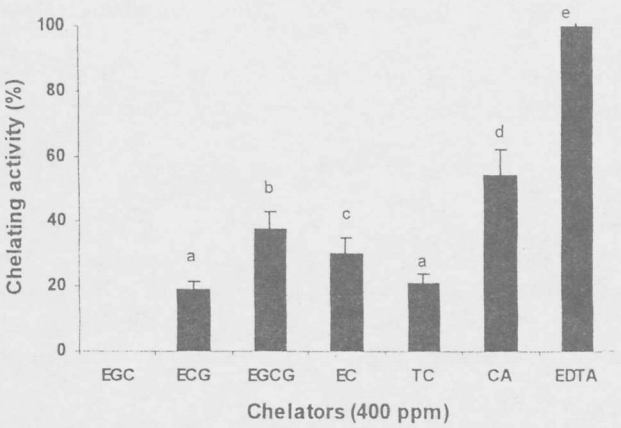

Fig. 3. Fe^{2+} (2 mM)-chelating effects of tea catechins at a concentration of 400 ppm compared with EDTA and CA. EGC, (-)-epigallocatechin; ECG, (-)-epicatechin gallate; EGCG, (-)-epigallocatechin gallate; EC, (-)-epicatechin; TC, commercial TC extract (86% purity); CA, citric acid; EDTA, ethylenediamine tetraacetic acid. Values = means ± SEM (n=4). Error bars with the different letters are significantly at $p<0.05$.

extract and individual standard TC had significantly ($p<0.05$) higher activities in scavenging DPPH free radical, with values from 94% to 98%, compared to α-tocopherol (VE) of 89% and L-ascorbic acid (AA) at 82% (Fig. 2). TC extract had significantly ($p<0.05$) higher activity in scavenging DPPH radical compared to individual TC. This is probably due to some additive effects of individual TC. Of the individual TC, EGCG showed the highest scavenging activity, with the value of 95%, followed by ECG, EGC and EC. However, no significant differences were observed among these catechins. Nanjo *et al.* (1996) reported that TC and their epimers showed 50% DPPH radical scavenging ability in the concentration range of 1 to 3 μM. The authors suggested that the galloy moiety attached to flavan-3-ol at position 3 had a strong scavenging ability on the DPPH radical and pointed out that the ortho-trihydroxyl group in the B-ring also played a more important role in free radical scavenging than the ortho-dihydroxyl group. Sánchez-Moreno *et al.* (1999) reported that VE had a lower activity of DPPH radical scavenging than polyphenolic constituents of wines. TC had a weaker chelating activity compared to citric acid (CA) and ethylenediamine tetraacetic acid (EDTA), both strong metal chelators (Fig. 3). EGCG had the highest activity (38%), followed by EC (30%), TC (22%), ECG (19%) and EGC (non-detectable), whereas, EDTA and CA had chelating activities of 100% and 54%, respectively. Record *et al.* (1996) reported that green tea extract at 50 ppm had significant metal chelating capacity. The free radical scavenging and metal chelation of TC may be responsible for their potent antioxidant activities in chicken meat systems.

Conclusion

Tea catechins extracted from green tea showed considerably antioxidant activity in chicken breast and thigh meat. The strong antioxidant activities observed are most likely due to strong free radical scavenging activities and to a lesser extent metal chelation.

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