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Original research article

Improved extraction of green tea components from teabags using the microwave oven

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ABSTRACT

The green tea (*Camellia sinensis*) catechins are strong antioxidants linked with potential health benefits. Based on previous studies, it was hypothesised that the typical household conditions for brewing green tea in a teabag – 200 mL freshly boiled water for 2–3 min, as per the manufacturers' instructions – were not sufficient to extract all the catechins and that a household microwave oven could be used to improve the extraction. The catechins and the two other main green tea components, caffeine and theanine, were monitored by HPLC. The typical household conditions only extracted 62% (61 mg/g tea), 76% (24 mg/g) and 80% (10 mg/g) of the catechins, caffeine and theanine, respectively, from the five varieties of teabags analysed. However, using microwave assisted extraction (MAE) by first brewing a teabag in 200 mL freshly boiled water for 0.5 min before irradiation for 1 min in a microwave oven (hot MAE), improved the extraction of the catechins and caffeine to 80% (80 mg/g) and 92% (29 mg/g), respectively, although the extraction of theanine was not affected. Therefore, the hot MAE technique could help maximise the extraction of the catechins for those who consume green tea for the potential health benefits of the catechins.

1. Introduction

Green tea (*Camellia sinensis*) is an abundant source of catechins, which are strong antioxidants that have been receiving considerable interest for their potential benefits in human health and food preservation (Khan and Mukhtar, 2007; Vuong et al., 2010, 2011d). For example, the catechins have been linked with protection against cardiovascular disease (CVD) (Kuriyama, 2008). Various catechin extracts from green tea have been shown to be active in humans; they lower low density lipoprotein (LDL) cholesterol, one of the major risk factors for CVD (Zheng et al., 2011). Other studies have shown that the mechanisms of actions for their cholesterol-lowering effect include an increase in the LDL receptor and a decrease in cholesterol synthesis (Bursill et al., 2001, 2007; Bursill and Roach, 2006, 2007).

Therefore, due to the potential benefits of the green tea catechins, several studies have been done on the various brewing conditions to maximise the extraction of these components from green tea. The results have defined optimal water brewing conditions including the temperature being maintained at 80 °C for 30 min and a ratio of tea to water of ≤1:20 g/mL (Komes et al., 2010; Lin et al., 2008; Peterson et al., 2005; Vuong et al., 2011b). However, these optimisation studies focused on loose-leaf green tea and were carried out under laboratory conditions. These conditions are very different from household brewing habits, where tea is simply brewed in boiled water and left at room temperature for a short time (≤3 min) before being consumed (Astill et al., 2001).

Although many people still traditionally prepare their green tea by brewing loose-leaf tea in boiled water, a more popular and convenient way of preparing green tea now is simply brewing a teabag in boiled water for 3 min, as suggested by the teabag manufacturers (Astill et al., 2001). However, compared to 30 min under optimal laboratory conditions, it was hypothesised that most of the catechins would not have time to infuse into the hot water during the short suggested brewing time of 3 min. This could be relevant because it may explain why results from epidemiological studies have shown that only high volumes (5–10 cups/day) of green tea are associated with health benefits (Kuriyama, 2008; Ui et al., 2009). In other words, consumers may not get the full health benefits of drinking green tea because the extraction of the catechins is not optimal under household brewing conditions.

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Therefore, this study investigated the impact of typical household teabag brewing conditions on the extraction of the catechins from green tea; the volume of boiled water used and the length of the brewing time were studied. Furthermore, microwave ovens are now ubiquitous in households, and in light of the finding that microwave assisted extraction (MAE) can be more effective at extracting bioactives from plant materials (Mandal et al., 2007), it was hypothesised that a household microwave oven could be used, in a time-efficient manner, to more effectively extract the catechins from green tea in teabags than simply following the current manufacturers' instructions. The extraction of the two other main green tea components, caffeine and theanine, was also monitored.

2. Materials and methods

2.1. Materials

Five different commercial green teas (*C. sinensis*) in teabags were purchased from a local supermarket (Woolworths, Tuggerah, NSW, Australia) in 2011 May: (1) Twinings Pure Green Tea, (2) Twinings Green Tea Pear & Apple, (3) Woolworths Select Green Tea, (4) Lipton Pure Green Tea and (5) Lipton Jasmine Green Tea. Three different boxes, containing 50 teabags per box, were purchased for each type of green tea for the analyses. The chemicals used in this study, L-tryptophan, L-theanine, caffeine, catechin (C), catechin gallate (CG), epicatechin (EC), epicatechin gallate (ECG), epigallocatechin (EGC), epigallocatechin gallate (EGCG), gallocatechin (GC), and gallocatechin gallate (GCG) were purchased from Sigma–Aldrich, Castle Hill, NSW, Australia. The structures of the eight catechins listed above are illustrated in Fig. 1. Orthophosphoric acid, High Pressure Liquid Chromatography (HPLC) grade acetonitrile and HPLC grade tetrahydrofuran were obtained from Lomb Scientific, Taren Point, NSW, Australia.

Ultra-pure (Type 1) de-ionised (DI) water was prepared by reverse osmosis and filtration using a Milli-Q Direct 16 system (Millipore Australia Pty Ltd, North Ryde, Australia). The DI water was used as solvent for all the brewing experiments with teabags.

2.2. Optimal brewing conditions

To determine the maximum amount of the green tea components available in a teabag (extractable components), the teabags were brewed under optimal laboratory extraction conditions as reported in a previous study (Vuong et al., 2011b). One teabag was extracted in 200 mL water maintained at 80 °C for 30 min while stirring constantly using a magnetic stirrer at 300 rpm. Triplicate extractions, each with a separate teabag, were done. The teabag was then moved up and down 10 times, removed from the brewing solution and squeezed. The resultant tea solution was placed on ice to cool it down to room temperature and then diluted 1:1 with 500 mM L-tryptophan in DI water, giving a final concentration for the internal standard of 250 mM. The solution was then filtered through a 0.45 μm cellulose syringe filter (Phenomenex Australia Pty. Ltd, Lane Cove, NSW, Australia) into brown glass vials for HPLC analysis.

2.3. Household brewing conditions

2.3.1. Impact of the volume of boiled water

To determine the impact of the volume of boiled water on the extraction of the tea components, the teabags were brewed in a range of water volumes from 100 mL, which is equivalent to the volume of a small cup, to 250 mL boiling water, which is equivalent to the volume of a mug as described by Astill et al. (2001). Water was brought to boiling in a household kettle and either 100, 150, 200 or 250 mL of the boiled water was added to a 250 mL glass beaker containing one teabag and left to brew at room temperature for 3 min without stirring. Triplicate extractions, each with a separate teabag, were carried out for each volume of boiled water. The teabag was then moved up and down 10 times, removed from the brewing solution and squeezed. The resultant tea solution was placed on ice to cool to room temperature and then diluted 1:1 with 500 mM L-tryptophan. The solution was finally filtered through a 0.45 μm cellulose syringe filter for HPLC analysis.

2.3.2. Impact of the length of brewing time

To determine the impact of the length of brewing time, a teabag was brewed in 200 mL of boiled water in a 250 mL glass beaker and allowed to stand at room temperature for various lengths of time ranging from 1 to 30 min. Triplicate extractions, each with a separate teabag, were done for each volume of boiled water. The teabag was then moved up and down 10 times, removed from the brewing solution and squeezed. The tea solution was placed on ice to cool to room temperature and then diluted 1:1 with 500 mM L-tryptophan. The solution was finally filtered through a 0.45 μm cellulose syringe filter for HPLC analysis.

The temperature of the tea solution for each of the triplicate teabag extractions at the end of each length of brewing time was also recorded using a DTM-3103 digital thermometer (Tecpel Co., Ltd, Taipei, Taiwan).

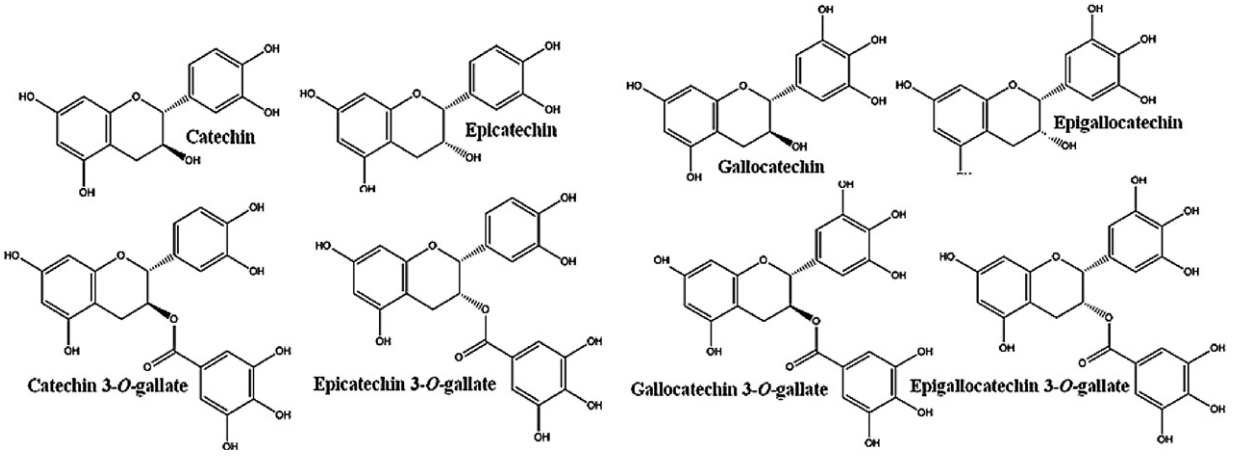

Fig. 1. Structure of the eight green tea catechins measured in this study.