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# Phenolic compounds in tea from Australian supermarkets

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**Abstract**

Phenolic compounds constitute 50–70% of tea water extract and are the main quality parameters for teas. Theaflavins (TF), thearubigins (TR) and theabrownins (TB) are the major polyphenols that determine the quality of black tea. These compounds were measured in 56 leaf teas and teabags sampled from Australian supermarkets in Queensland. The various quantities of TF, ranging from 0.29% to 1.25%, indicate a quality difference that exists among the teas studied. Low TF content in black tea may be due to over-fermenting and/or long periods of storage. The solubility of TR and TB from teabags ranged from 82% to 92%, indicating that the permeability of teabags was variable. Variable quantities of TF in Australian teas show instability and a tendency of TF to oxidize during storage. Total polyphenols in green teas ranged from 14% to 34%, indicating a large variation, which was not reflected in price. The solubility of total polyphenols from teabags has been proposed as a useful quality index of the filtering paper used for the teabags. This chemical analysis of phenolic compounds in commercial teas may be a potential tool for the quality control of Australian manufactured and imported teas in Australian markets.


*Keywords:* Tea; Polyphenols; Theaflavins; Thearubigins; Theabrownins; Quality

## 1. Introduction

The major proportion (ca. 90%) of total phenolic compounds in tea is comprised of flavonoids, from green tea catechins (flavanols and flavanol gallates) to their complex oxidation products, theaflavins (TF) and thearubigins (TR, mistakenly presented as thearubigens in some literature) in black tea (Harbowy & Balentine, 1997; Lakenbrink, Lapczynski, Maiwald, & Engelhardt, 2000). TF and TR are soluble in hot water and represent 20–35% (w/w) of dry tea, from which about 45% of the tea constituents can be infused into hot water (Xiao, 1994). Tea phenolic compounds, known as tea polyphenols (Harbowy & Balentine, 1997), previously called tea tannins (Bokuchava & Skobeleva, 1969), have been regarded as the quality parameters or indicators of tea (Deb & Ullah, 1968; Ding, Kuhr, & Engelhardt, 1992; Obanda, Owuor, & Njuguna, 1992). In particular, theaflavins (TF) were used to assess the market value (Hilton & Ellis, 1972; Owuor, Reeves, & Wanyoko, 1986), clonal variations (Owuor & Obanda, 1995) and seasonal quality variations of black tea (Malec & Vigo, 1988). Thus, analysis of tea polyphenols is an effective method for the determination of tea quality.

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Traditional methods for the preparation and determination of polyphenols in fresh tea shoots or manufactured teas have been described by several researchers (Roberts, 1962; Roberts & Myers, 1958; Roberts & Smith, 1961). The most common methods are paper chromatography (Oshima & Nakabayashi, 1953a; Roberts, 1962; Roberts, Cartwright, & Oldschool, 1957; Roberts, Cartwright, & Wood, 1956), column chromatography (Oshima & Nakabayashi, 1953b; Whitehead & Temple, 1992) and colorimetric measurement (Muralidharan, 1997; Oshima & Nakabayashi, 1953c; Roberts & Smith, 1961). All those methods are based on either the oxidation or reduction properties of tea polyphenols. More recently developed analytical techniques are used to isolate, identify and determine individual polyphenolic compounds by HPLC (Harbowy & Balentine, 1997; Temple & Clifford, 1997; Yao & Nursten, 1997, 1998). However, colorimetric or spectrophotometric methods are still the most widely used, due to their simplicity for the determination of total phenolic compounds, TF and TR in tea (Harbowy & Balentine, 1997; Lakenbrink et al., 2000), particularly for tea industries.

Theaflavins, thearubigins and theabrownins are complex phenolic compounds deriving from the oxidation of catechins and their gallates during the fermentation stage of black tea processing (Roberts, 1962; Zhang, 1987). In the black tea trade, the contents of these compounds are measured as part of a regular quality control procedure. TF are the first stable oxidation products formed in tea fermentation, and refer to the intermediate compounds formed during the oxidation of catechins and catechin gallates. Theaflavins undergo further oxidation during fermentation, to form more polymerised thearubigins, and then condensed theabrownins, which are found to be polymerised thearubigins linked with proteins (Yuan, 1983; Zhang, 1987). TR are a group of compounds formerly recognised as insoluble fractions, SI and SII, of ethyl acetate extraction (Roberts et al., 1956). TR was further separated by butanol into soluble TR and insoluble TR (Yuan, 1983). Of those compounds, TF contributes the brisk and astringent taste and bright golden colour to black tea quality, while TR contribute the reddish colour and richness in taste, totally termed 'body' to black tea (Roberts, 1962). Therefore, both classes of compounds are associated with quality and other desirable liquor characters (Bhatia, 1960; Roberts, 1962). In contrast, TB endows tea liquor and leaf with a dark brown colour, which has a negative effect on tea quality (Yuan, 1983). Therefore, analyses of these three groups of phenolic compounds can be used as a objective methods in the determination of black tea quality.

Takeo and Oosawa (1976) studied the whole profile of phenolic compounds by comparing the price and sensory characteristics of black tea. However, no previous studies have been reported on the phenolic compounds in teas from Australian supermarkets. This is the first systematic survey of teas from Australian markets for the quantification of tea polyphenols, and could have potential for the quality assessment of teas in this market.

## 2. Materials and methods

### 2.1. Samples

Leaf tea and teabags, commercially available from three major supermarkets (Woolworths, Coles and Franklins) in Brisbane, Gatton and Toowoomba of Queensland, Australia, were randomly sampled and used for this study, except for one leaf tea that was manufactured in the laboratory from the fresh tea leaves obtained from commercial tea estates at Malanda in north Queensland. This leaf was used as a representative of fresh Australian manufactured teas for the supermarkets for a comparison in this study. One crude black tea sample provided by the same tea estate was used for the comparison.

Teabags were either heat-sealed, as in the UK-type, or double chamber US-type. The sampling method used in this study was based on the international standard method [ISO 1839 (BS 5987), 1980].

### 2.2. Moisture

Tea moisture was measured using a vacuum oven based on an international standard method [ISO 1573 (BS 6049-2), 1980].

### 2.3. Total phenolic compounds

#### 2.3.1. General

The method was based on the description of tea-researchers (C. M. C., 1991; Roberts, 1962) with modification of the recent work (Muralidharan, 1997; Yao, Chen, & Cheng, 1993; Yao, Cheng, Chen, & Liu, 1992). Details of the method are as follows.

#### 2.3.2. Preparation of the tea solution

Boiling water (200 ml) was added to 2 g leaf tea or 1 teabag (ca. 2 g) in a 250 ml conical flask and stirred by a magnetic bar on a hot plate at 90 °C for 10 min. Then, the solution was filtered through cotton wool and the residue was washed with distilled water ($3 \times 10$ ml). The tea solution was combined, then cooled to room temperature and finally diluted to 250 ml with distilled water. The tea solution was prepared in duplicate.

#### 2.3.3. Tartrate solution

$FeSO_4$ (1 g) and $KNaC_4H_4O_6$ (5 g) were dissolved in distilled water and made up to 1000 ml.