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Antioxidant activity of white, green and black tea obtained from the same tea cultivar

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ABSTRACT

The present study explored what effect manufacturing has on the antioxidant properties of teas coming from a single cultivar but processed differently to give a white, two black (Orthodox and CTC) and two green (low-caffeine and non-decaffeinated) teas. Total phenol (TPC), flavonoids (TFC), theaflavins, individual catechins content, and chelating activity were also investigated. Using the ABTS, ORAC and LDL assays the following 'antioxidant profile' was obtained: green ≥ low-caffeine green > white ≥ black Orthodox > black CTC, with statistically significant correlation between ORAC and LDL assays ($r^2 = 0.444$, $p = 0.0067$), whereas TPC and TFC significantly correlate with the ABTS one ($r^2 = 0.871$, $p = 0.000$ and $r^2 = 0.438$, $p = 0.007$, respectively). Metal chelating activity, which was lowest in the green teas, does not correlate with antioxidant activity but appears to be influenced by theaflavins content. The results contribute to better understand how the manufacturing process influences the antioxidant activity of tea when variables (geographical region, environmental conditions, cultivar type, plucking techniques) are kept to a minimum. Secondly, we show that novel African green, white and black Orthodox teas, made from tea varieties typically used in black CTC tea production, may have potential health benefits comparable with commonly consumed teas.

1. Introduction

Tea is the most popular beverage after water, enjoyed by many people across the globe, and which is receiving continual interest due to the many beneficial health effects associated with its regular consumption.

All varieties of tea are produced from the young, tender leaves of the *Camellia sinensis* (L.) (family *Theaceae*), a perennial, evergreen, leafy crop that enjoys warm and humid climates with plenty of rainfall. Freshly, plucked leaves are then processed to give black tea (fermented), oolong tea (semi-fermented), green and white teas (unfermented). Fermentation consists in the enzymatic oxidation by endogenous polyphenol oxidases and peroxidases of tea polyphenols, namely colorless flavanols, that are partially converted into theaflavins and thearubigins, responsible for the characteristic aroma and color of black and oolong teas (Obanda, Owuor, & Mang'oka, 2004). This oxidation process is accelerated by rupturing the withered tea leaves using orthodox rollers or machines (CTC: crush-tear-curl), so that the oxidases released can more readily react with oxygen. In unfermented teas, fermentation of the withered leaves is prevented by inactivating the endogenous enzymes through steaming or heating using different methods (pan frying, roasting, baking) before the rolling and drying process. Instead, white tea is the least processed in that it goes only through sunshine withering and drying. Furthermore, white teas are characterized by the fact that only buds still covered with fine white hair, and one or two very young leaves are used (Balentine, 1992).

Consumers of black tea far outweigh those of green tea worldwide. However, in recent times green tea consumption has increased especially in the West, due to the numerous studies that indicate a wide variety of health benefits following its regular consumption: reduced risk of cardiovascular disease and certain types of cancer, inflammatory bowel, liver and neurodegenerative diseases, diabetes, and even weight loss (Dufresne & Farnworth, 2001). These health benefits are attributed to its high content of catechins which have been described as potent antioxidants ameliorating disease states related to reactive oxygen species (ROS) (Rietveld & Wiseman, 2003). Since tea leaves are processed differently to produce black, green, oolong and white teas, it is of interest to know which tea could potentially be more beneficial in terms of antioxidant activity. Many studies compare the activities of these teas but a conclusive answer has yet to be reached. Generally, antioxidant activity decreases in the order: green tea > oolong tea > black tea (Richelle, Tavazzi, & Offord, 2001; Roginsky, Barsukova, Hsu, & Kilmartin, 2003; von Gadow, Joubert, & Hansmann, 1997) although some studies show that black teas are better than green ones (Hoff & Singleton, 1977; Khokhar &

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Magnusdottir, 2002; Venditti et al., 2010) while others report the absence of any significant differences (Hodgson et al., 1999; Lin, Juan, Chen, Liang, & Lin, 1996). The numerous variables that affect tea components according to cultivar type, growth conditions (season, climate, soil), horticultural practices (mechanical- or hand-plucking, age of leaves) and the different technologies of the tea companies may account for these conflicting reports (Kan, 1980; Wicremasinghe, 1974). Hence, it is not strictly correct to compare the antioxidant activities of black, white, and green teas unless these variables are minimized.

Therefore, the present study was carried out to explore what effect manufacturing has on the antioxidant properties of teas coming from a single cultivar (grown and plucked under the same conditions) but processed differently in the same factory to give two black teas (Orthodox and CTC), two green teas (low-caffeine and non-decaffeinated) and one white tea. Total phenol, flavonoids, theaflavins, individual catechins and caffeine content, as well as chelating activity were also investigated.

2. Materials and methods

2.1. Chemicals and equipment

All reagents, standards for HPLC analysis and solvents of highest purity available, were purchased from Sigma-Aldrich Chemical Co. (Milan, Italy) and used as received. Ultrapure water was used throughout and obtained from a Milli-Q system from Millipore (Milford, MA), except for preparation of teas where bottled mineral water purchased from local retail shops was used.

Spectrophotometric measurements were recorded on a UV Kontron 941 spectrophotometer or on a microplate reader (Synergy HT, Biotek, Winooski, VT, USA).

2.2. Tea samples and preparation

Five tea samples processed from hand plucked leaves of the superior cultivar PC108, bred in Malawi for typical black CTC tea production by the Tea Research Foundation based in Mulanje, and grown on a private estate, were analyzed. The green leaves had been harvested from the same field at three different times: February (typically overcast, wet, warm conditions), April (bright sunny days and cool nights) and September (hot clear days and warm nights) 2008. Fresh leaves were then processed according to the flow-chart reported in Fig. 1 to give five different teas: white, green, low-caffeine green, black CTC and black Orthodox teas. The withering was done in troughs and ambient or heated air was blown into a plenum chamber and up through the leaf. In order to achieve the target moisture content, the withering time varied depending on the prevailing weather conditions and conditions of leaf on receipt into the factory. The target moisture content for all teas at the end of the drying process carried out in a fluid bed drier was 3–4%.

Prior to preparation of hot tea infusions, the teas were ground using a pestle and mortar to obtain a homogeneous fine powder. The infusions were prepared by pouring 20 ml of mineral water at 90 °C on 0.5 g of tea and brewed for 7 min. They were then filtered through Whatman paper filters 43–48 μm and diluted appropriately with water according to each specific assay.

2.3. Total phenol content (TPC)

Total phenol content in the tea infusions was determined using the Folin–Ciocalteu reagent (Singleton, Orthofer, Lamuela-Raventos, & Lester, 1999). To 1.975 ml water, 0.125 ml of Folin–Ciocalteu reagent followed by 0.025 ml of tea previously diluted 5 fold, or appropriately diluted gallic acid standard ethanolic solution, or water as blank, were

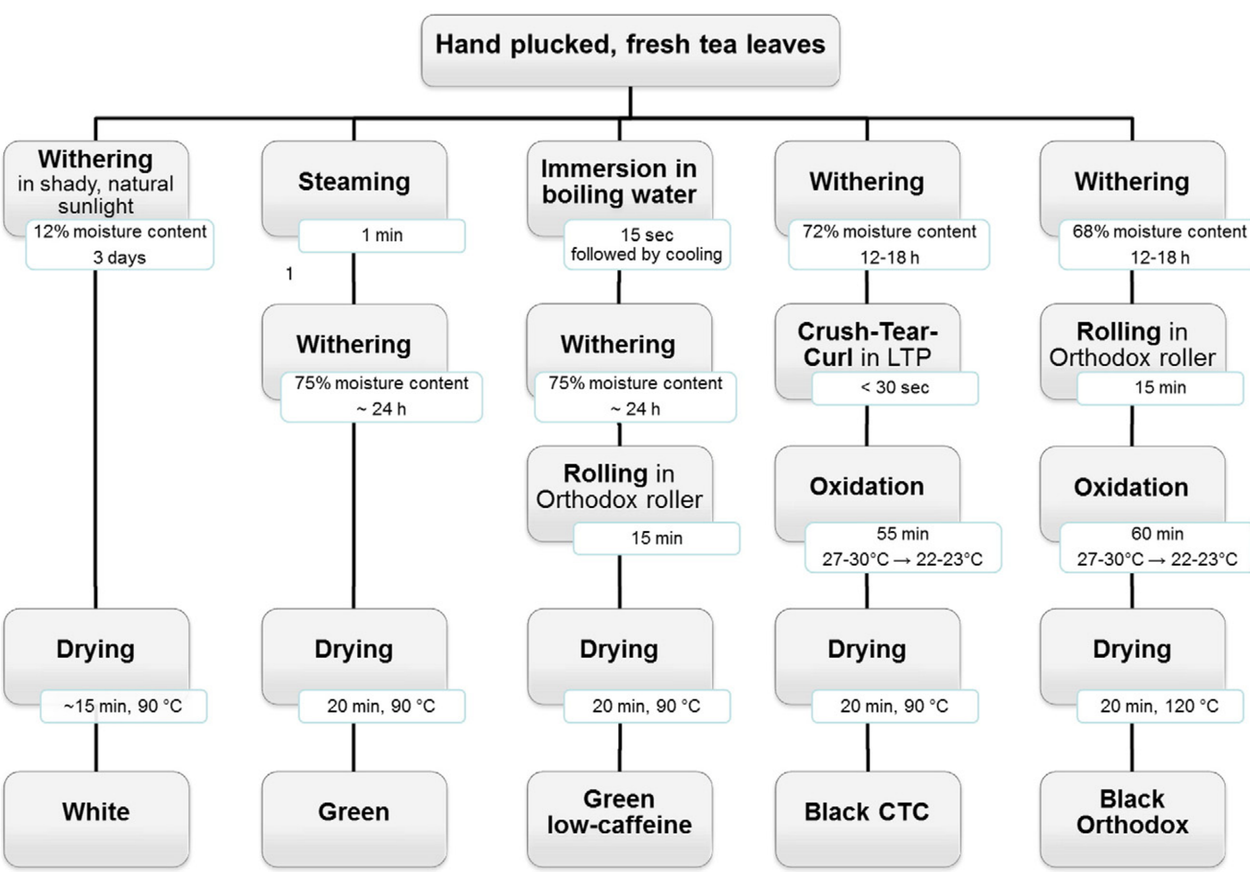

Fig. 1. Flow chart showing the different stages in the manufacture of the different teas investigated. LTP = Lawrie tea processor; CTC = crush-tear-curl (see Materials and methods for details).