Chapter

Introductory Chapter: Tea - Chemistry and Pharmacology

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1. Introduction

Tea is one of the two most consumed beverages worldwide, the other being coffee, and the geographic distribution of each is well established—coffee is more abundantly consumed in Europe and the United States, while the rest of the world clearly prefers tea. Tea is prepared from the leaves, stems or buds of various plants of the genus *Camellia*, most commonly from *C. sinensis*, and the final content in polyphenols, minerals, vitamins and other compounds, including caffeine, is strongly dependent on the type of processing. For example, in green tea, the levels of catechins are much higher than in black tea, where tannins dominate. The predominant types of tea, classified with base on their flavour, colour and composition, are green tea, which does not undergo fermentation; black tea, which results from the full fermentation of the plant parts; and oolong tea, which corresponds to semi-fermentation [1–4].

There is a vast body of studies that address the effects on the many types of tea constituents on human health. While initially most studies were focused on the antioxidant effects of polyphenols, nowadays, it is well established that tea is a pleiotropic agent on human health. Catechins and theaflavins are the predominant polyphenols in tea, and their redox activity as metal chelators and reactive species scavengers, well characterized in vitro, was initially pointed as one of the most important tea effects on human health. Continued studies have shown that on top of those modulating properties, tea components also display unique pharmacological properties, in particular enzymatic inhibition and transporter modulation [5, 6]. In general, polyphenol intake is associated with reduced risks of stroke, myocardial infarction and diabetes, and it has been linked to improved blood flow and pressure, improved inflammation response and an overall improved lipid status [1, 5, 7, 8] (**Figure 1**).

Among the many polyphenols studied in tea, one that has attracted most attention is quercetin, a flavone with a large number of well-characterized in vitro and in vivo activities, which is a good example of tea chemistry. Quercetin is a powerful metal chelator and radical scavenger, and although it undergoes extensive metabolization upon ingestion, it still retains a good generic antioxidant activity. Due to its role as reactive species modulator, quercetin has the ability to combat their harmful effects that are present in Alzheimer's disease, diabetes, hypertension and age-related eye degenerative diseases, among many others [8–16]. While most of these effects are linked to the antioxidant properties of quercetin, this flavone is also able to display a pro-oxidant effect in specific situations, like in the presence of high iron content. This pro-oxidant activity has been linked to the pro-apoptotic effect of quercetin on tumour cells, associated with its p53 activation effect in such cells; moreover, quercetin is also a modulator of various cellular cytokines and signal transduction pathways and plays an important role as chemotherapy adjuvant in various types of human cancers [7, 8, 11, 17, 18].

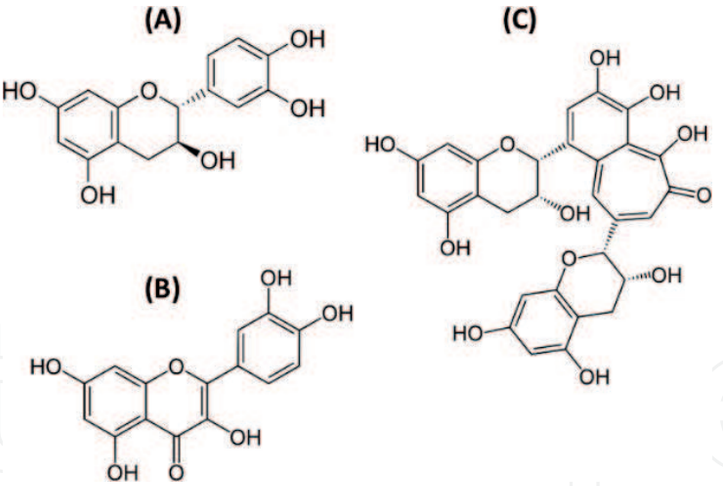

Figure 1.
Structure of (A) catechin, (B) quercetin and (C) theaflavin.

Like quercetin, the effect of tea catechins on human health is also well characterized, not only at the antioxidant/pro-oxidant level but also at the immunomodulatory level and at the central nervous system level. Catechins display a synergistic effect contributing to the inhibition of cerebral Aβ plaque deposition in Alzheimer's and also display a protective role towards α-synuclein, contributing to the prevention and management of Parkinson's [19–22]. The neuroprotective effects of catechins and other polyphenols are not restricted to these two diseases, displaying a widespread protective effect in the nervous system, particularly in dopaminergic neurons, and contributing to the prevention or amelioration of age-related neuronal decay [19, 20, 23]; many of these effects are due to the activation of signalling pathways critical for synaptic plasticity, neuroinflammatory control, cell renewal, cerebrovascular flow and memory decline [24–26].

Although metals are typically associated to oxidative stress, they are also important micronutrients. The most well-known cases are the structural roles of Fe, Cu, Zn and Co ions in biomolecules, and tea is also an important source of these micronutrients. Besides these, higher plants also have specific requirements for other essential elements, namely, B, Cl, Mn, Mo and Ni. Many of these metals are redox-active essential protein cofactors and protein stabilizers and are found in varying amounts in consumed tea. The levels of each metal in the consumed tea depend strongly on the plant growth conditions and partially on the preparation but contribute strongly to the overall micronutrient homeostasis [27, 28].

More recently, a strong link between phytochemicals and oral health has been established, based on the role these compounds display in microbes. Tea, in particular green tea, has been linked to lower incidence of periodontal disease, dental caries and halitosis, as well as to a lower smoke-dependent inflammation. These effects are greatly dependent on the capacity of tea polyphenols to inhibit or diminish dental biofilm formation but also to inhibit bacterial ATPases, interfering with bacterial energy metabolism and bacterial enzymes involved in DNA synthesis, interfering with bacterial replication [29–38].

This plethora of health-promoting effects of tea constituents is at the origin of the functional food approach to tea, in which tea, in its native drink form, or as supplement, is marketed as an unsurmountable supplement, contributing to a healthier lifestyle. Also, tea and its constituents are also used in the food industry, in particular as antioxidants, preventing and retarding food breakdown, and as food supplements [39–42]. However, and in spite of all the advantages associated with tea, functional supplements must be carefully considered—although tea extracts

have been shown to promote health, with no observed counter-indications or side effects in most studies, highly purified supplements have been linked to toxic events from gastrointestinal irritation to hepatic injuries, depending not only on the type of supplement but also on the type of intake, in fasting vs. after meals or in pills vs. infusion [43, 44].

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