Clinical Nutrition (2006) **25**, 790–796

ELSEVIER

Clinical Nutrition

http://intl.elsevierhealth.com/journals/clnu

ORIGINAL ARTICLE

The effect of green tea in oxidative stress

Susana Coimbra[a,*], Elisabeth Castro[a,b], Petronila Rocha-Pereira[b,c], Irene Rebelo[a,b], Susana Rocha[a,b], Alice Santos-Silva[a,b]

[a]*Faculdade Farmácia, Serviço Bioquímica, Universidade Porto, Portugal*
[b]*Instituto de Biologia Molecular e Celular, Universidade Porto, Portugal*
[c]*Departamento Química, Universidade Beira Interior, Portugal*

Received 17 June 2005; accepted 22 January 2006

KEYWORDS
Green tea;
Oxidative stress;
Lipid peroxidation;
Camelia sinnensis;
Total antioxidant status;
Erythrocyte membrane

Summary
Background & aims: Green tea, an infusion prepared with the leaves of *Camellia sinensis* is particularly rich in flavonoids, which are strong antioxidants. Tea drinking, by providing antioxidants, may become valuable in several oxidative stress conditions. Our aim was to evaluate the effect of green tea drinking on some factors reflecting the development of oxidative stress in plasma and in erythrocytes.
Methods: The study was performed in 34 Portuguese subjects. We evaluated the total antioxidant status (TAS), the lipid peroxidation products—malonyldialdehyde (MDA) and malonyldialdehyde+4-hydroxy-2(E)-nonenal (MDA+4-HNE)—and the oxidative changes in erythrocyte membrane, namely membrane bound haemoglobin (MBH) and the band 3 profile. Analytical evaluations were performed after 3 weeks drinking 1 l of water daily, and after 4 weeks drinking 1 l of green tea daily. Tea was prepared daily at the same conditions of temperature, time of infusion and concentration.
Results: After green tea drinking, we found a significant reduction in serum levels of MDA and MDA+4-HNE and in the oxidative stress within the erythrocyte, as suggested by a significantly lower value of MBH and by changes in band 3 profile towards a normal mean profile, namely an increase in the band 3 monomer. A rise in the antioxidant capacity was also observed.
Conclusions: Our data suggest for green tea drinking a beneficial effect, by reducing the development or the enhancement of oxidative stress and, therefore, protecting the individual for oxidative stress diseases. Moreover, we propose further studies about the value of band 3 profile and of MBH in providing a cumulative measurement of the effect of green tea drinking upon the oxidative stress in cells. Moreover, further studies are also needed, to clarify the effect of green tea consumption, the value of regular green tea consumption and the way it should be prepared to reach a healthy effect.

*Corresponding author. Tel.: +351 962677495; fax: +351 222003977.
E-mail address: susana.coimbra@netcabo.pt (S. Coimbra).

0261-5614/$ - see front matter © 2006 Elsevier Ltd and European Society for Clinical Nutrition and Metabolism. All rights reserved.
doi:10.1016/j.clnu.2006.01.022

Introduction

Tea, an infusion prepared with the leaves of *Camellia sinensis*, is the most widely consumed drink in the world, besides water. Differences in the processing of the leaves seem to underlie the different chemical and physiological properties of green, oolong and black tea.[1] Tea, particularly green tea, is an important source of flavonoids, namely catechins, which are strong antioxidants. Among cathechins, epigallocatechin gallate is the more powerful antioxidant in vitro[2] and it is the most abundant polyphenol in green tea.[3]

There is good evidence that green tea catechins have a role in the protection against degenerative diseases.[4] Tea drinking, by providing antioxidants, may become valuable in several chronic diseases known as oxidative stress conditions,[5] such as the cardiovascular diseases (CVD).[4,6] These pathologies are one of the major causes of mortality and morbidity in the western world.[7] The search for new factors leading to a decrease in the prevalence of CVD and other oxidative stress diseases becomes, therefore, valuable.

Several epidemiological, clinical and laboratorial studies suggest that tea drinking, particularly green and black tea drinking, may provide a significant protection for CVD. This protection seems to increase with the volume of tea drank daily, as showed a study performed with Japanese men and women for 12 years.[8] An increase in daily tea drinking of 711 ml was also reported to decrease the risk of myocardial infarction by 11%.[9] Endothelium-dependent vasodilatation, which is known to be impaired in heart disease patients and in subjects with high cholesterol levels, was reported to improve significantly after drinking tea daily for 4 weeks.[10] The potential protective role played by green tea against injurious effects of reactive oxygen species in human microvascular endothelial cells was evaluated and the results showed that green tea polyphenol can act as a biological antioxidant in a cell culture experimental model and prevent oxidative stress-induced cytotoxicity in endothelial cells.[11]

It has been attributed to green tea drinking a decrease in lipid peroxidation, in free radical generation, in LDL-oxidation and in the development of oxidative stress.[12–15] However, conflicting results have been reported about the antioxidant activity of green tea consumption, in what concerns the effect on plasma lipid profile and plasma lipid peroxidation.[16–19] The controversial reported data is probably confounded by dietary and lifestyle habits, by the way tea is consumed, in a regular way or not, and by the way tea is prepared and the concentration and volume of green tea consumption. Therefore, further studies are warranted to clarify the value of green tea drinking.

Tea polyphenols may act as antioxidants by scavenging reactive oxygen and nitrogen species and by chelating redox-active transition metal ions, and may also act indirectly as antioxidants through, among other mechanisms, the inhibition of ''pro-oxidant'' enzymes and induction of antioxidant enzymes.[20] The antioxidant properties of flavonoids may therefore, protect tissues, cells and plasma constituents against oxidative damage.[21,22]

Presenting a limited biosynthesis capacity and poor repair mechanisms, the circulating red blood cell (RBC) suffers and accumulates physical and chemical changes, which become more pronounced with cell age or with cell damage occurring whenever an unusual physical or chemical stress develops.[23,24] The removal of senescent or damaged RBCs seems to involve the development of a senescent neoantigen on the plasma membrane surface.[25] This neoantigen is immunologically related to band 3, a RBC transmembrane protein.[26] Modifications in this protein by proteolytic cleavage, clustering or exposure of unusual epitopes, triggers the binding of specific anti-band 3 autoantibodies and complement activation, marking the cell for death.[24,27]

The degradation of the RBC metabolism and of the antioxidant defences, in senescent or damaged RBC by favouring the development of oxidative stress, allows haemoglobin oxidation and its linkage to band 3, promoting the aggregation of band 3 protein and the binding of natural anti-band 3 autoantibodies.[28] Previous studies performed in several oxidative stress conditions, namely in myocardial infarction, in ischemic stroke, in high competition physical exercise, in pregnancy, and in psoriasis, showed that the evaluation of membrane-bound haemoglobin (MBH) and of the band 3 profile may provide good markers of erythrocyte ageing or damage.[29–32]

Considering the controversial about the used plasmatic markers to evaluate the effect of green tea drinking on oxidative stress,[16–18] we found as important, the measurement of MBH and of the band 3 profile as potential cumulative erythrocyte markers of oxidative stress.

We aimed to study the effect of green tea drinking on some factors reflecting the development of oxidative stress, by evaluating plasma total antioxidant status and lipid peroxidation products; oxidative changes in the erythrocyte membrane, namely MBH and the band 3 profile.