Food Chemistry 141 (2013) 3335–3340

Contents lists available at SciVerse ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

The effect of processing on chlorogenic acid content of commercially available coffee

Charlotte E. Mills, Maria Jose Oruna-Concha, Donald S. Mottram, Glenn R. Gibson, Jeremy P.E. Spencer *

Department of Food and Nutritional Sciences, School of Chemistry, Food and Pharmacy, University of Reading, Whiteknights, Reading RG6 6AP, UK

ARTICLE INFO

Article history:
Received 14 February 2013
Received in revised form 29 April 2013
Accepted 4 June 2013
Available online 13 June 2013

Keywords:
Coffee (*Coffea* spp.)
Instant coffee
Decaffeinated coffee
Chlorogenic acids
Roasting

ABSTRACT

Chlorogenic acids (CGA) are a class of polyphenols noted for their health benefits. These compounds were identified and quantified, using LC–MS and HPLC, in commercially available coffees which varied in processing conditions. Analysis of ground and instant coffees indicated the presence of caffeoylquinic acids (CQA), feruloylquinic acids (FQA) and dicaffeoylquinic acids (diCQA) in all 18 samples tested. 5-CQA was present at the highest levels, between 25 and 30% of total CGA; subsequent relative quantities were: 4-CQA > 3-CQA > 5-FQA > 4-FQA > diCQA (sum of 3,4, 3,5 and 4,5-diCQA). CGA content varied greatly (27.33–121.25 mg/200 ml coffee brew), driven primarily by the degree of coffee bean roasting (a high amount of roasting had a detrimental effect on CGA content). These results highlight the broad range of CGA quantity in commercial coffee and demonstrate that coffee choice is important in delivering optimum CGA intake to consumers.

1. Introduction

Coffee is an extremely popular beverage throughout the world and is the third most commonly consumed after only water and tea (Wang & Ho, 2009). As well as being a rich source of methylxanthines, in particular caffeine (Bunker & McWilliams, 1979), it is also considered to contain relatively high levels of hydroxycinnamates, particularly chlorogenic acids (CGA), which have been noted for their health benefits (Tavares et al., 2012; Vita, 2005; Yang, Wang, Lu, & Picinich, 2009). CGA consists of a quinic acid moiety esterified to one or more hydroxycinnamic acids and to date around 45 CGA have been identified in coffee (Clifford & Jarvis, 1988; Clifford, Johnston, Knight, & Kuhnert, 2003; Clifford, Knight, Surucu, & Kuhnert, 2006; Clifford, Marks, Knight, & Kuhnert, 2006). A 200 ml serving of coffee delivers approximately 15–325 mg of CGA (Richelle, Tavazzi, & Offord, 2001), contributing between 0.5 and 1.0 g intake per day in regular coffee drinkers (del Castillo, Ames, & Gordon, 2002). The most abundant hydroxycinnamic acid derivatives in coffee are quinic acid esters of caffeic (one or two moieties per molecule) and ferulic acid (Fig. 1). Although data are limited, studies suggest that CGA may possess potential health effects, including an ability to reduce the risk of cardiovascular disease (Mubarak et al., 2012) and type two diabetes (van Dijk et al., 2009), whilst there are suggested improvements in cognitive function (Cropley et al., 2012).

Although data indicate that coffee is capable of delivering relatively high amounts of these potentially beneficial compounds, there is limited information regarding the influence of coffee processing on precise levels of CGA delivered per cup. There are a number of processing steps in coffee production which may have a significant impact on CGA content, such as bean fermentation, bean roasting, freeze or spray drying (in the case of instant coffee), decaffeination and/or blending (with non-coffee components). Amongst these, the roasting stage has the most profound effect on the chemical composition, as the low moisture content of the bean and high temperatures facilitate the Maillard reaction; a complex chain of reactions known to lead to many and varying aroma characteristics associated with coffee. It has been reported that CGA are unstable at high temperatures (Dawidowicz & Typek, 2010; Dawidowicz & Typek, 2011), which is likely to be responsible for roasting having a detrimental effect on CGA content (Farah, de Paulis, Trugo, & Martin, 2005; Moon, Yoo, & Shibamoto, 2009; Perrone, Farah, Donangelo, de Paulis, & Martin, 2008; Trugo & Macrae, 1984). Despite there being information of the effects of bean roasting on CGA levels, data relating to the influence of other processing conditions on CGA are limited, and investigations using commercial coffee available in retail outlets, have not been reported. The aim of this study was to investigate CGA levels of a range of commercial coffee brews, which have been subject to different processing and preparation methods in order to understand the potential variation in the amount of CGA consumed by coffee drinkers.

* Corresponding author. Tel.: +44 118 378 8724; fax: +44 118 378 7708.
E-mail address: j.p.e.spencer@reading.ac.uk (J.P.E. Spencer).

0308-8146/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.foodchem.2013.06.014

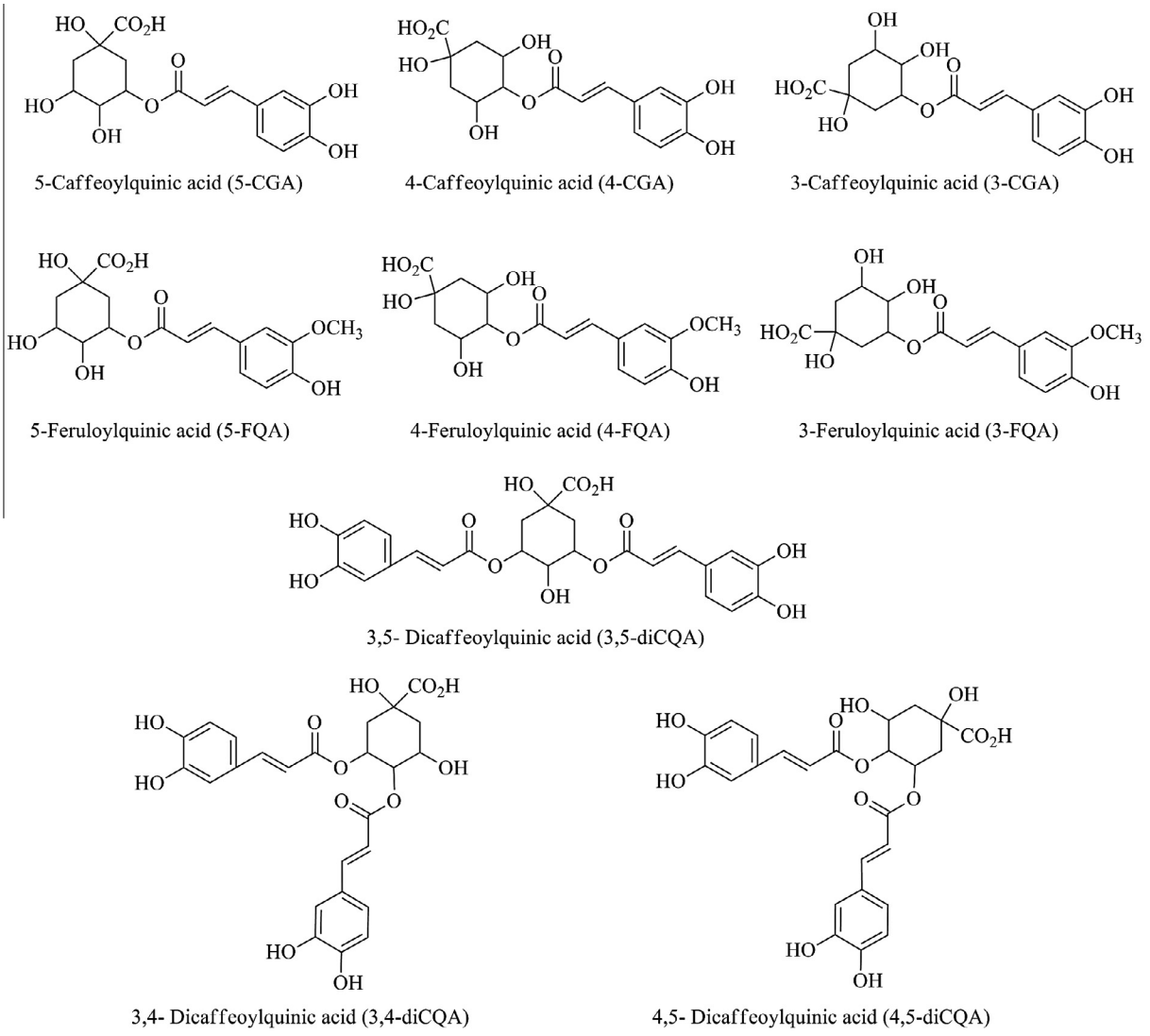

Fig. 1. Structural representation of the major chlorogenic acids found in coffee.

2. Materials and methods

2.1. Chemicals and reagents

5-Caffeoylquinic acid (5-CQA), crystallised zinc acetate, glacial acetic acid and potassium ferrocyanide trihydrate, were all obtained from Sigma–Aldrich (Dorset, UK). Ethanol, HPLC grade; methanol, acetonitrile and hydrochloric acid, LC–MS grade; formic acid, acetonitrile, methanol and water were from Fischer Scientific (Loughborough, UK). Deionised water was prepared using a Purite dispenser.

2.2. Coffee sample preparation

The coffee samples were obtained from two local supermarkets (Tables 1 and 2). Pre-ground coffee (20 g) was extracted by adding 900 ml boiled distilled water (left to stand for 20 s) for 4 min in an 8 cup caffetiere, before plunging through the metal mesh filter. Instant coffee (0.45 g) was extracted by addition of 50 ml of boiled distilled water. All coffee samples were placed on ice immediately after preparation. Prior to either LC–MS^n or HPLC analysis, 1 ml of Carrez I solution (1 M crystallised zinc acetate, acidified with glacial acetic acid), 1 ml Carrez II solution (250 mM potassium ferrocyanide trihydrate) and 0.8 ml ethanol (100%) was added to 4 ml of the coffee extracts for clarification. The samples were vortexed and left to stand for 10 min after which they were centrifuged at 930*g* for 10 min then filtered through a 0.45 μm syringe filter. All extractions were carried out in triplicate for each coffee. Quantities were expressed as 5-CQA equivalents per 200 ml cup, assuming 1.8 g of instant coffee and 11 g of fresh coffee is used, as recommended for domestic use.

Table 1
Sainsbury's pre-ground coffee details.

Name[a]	Roast grade[b]	% *C. arabica*: *C. robusta*	Other
Breakfast	2	100:0	
All day	3	95:5	
Viennese style	3	85:15	12.5% fig
Italian style	4	95:5	
New York style	4	100:0	50% Decaffeinated
French style	4	40:60	45% Chicory
Continental style	5	80:20	
After dinner	5	70:30	

[a] Supermarkets own label.
[b] Roast grade as established by manufacturer.