Chemical and bioactive composition of coffee by-products: from field to roasting

Marlene Machado[1] (marlenemachado753@gmail.com), Liliana Espírito Santo[1], Susana Machado[1], Joana C. Lobo[1], Anabela S. G. Costa[1], Maria B. P. P. Oliveira[1], Helena Ferreira[2], Rita C. Alves[1]
[1]REQUIMTE/LAQV, Dep. of Chemical Sciences, Fac. of Pharmacy, Univ. of Porto, Portugal;
[2]UCIBIO/i4HB, Dep. of Biological Sciences, Fac. of Pharmacy, Univ. of Porto, Portugal

Introduction

Coffee companies produce considerable amounts of by-products. It is, therefore, crucial to find ways to valorize them, avoiding their disposal into the environment [1].

Aim: to evaluate the chemical and bioactive composition of different by-products from coffee processing to roast, namely, pulp **(A)**, husk **(B)**, parchment **(C)**, defective beans **(D)**, green coffee sieving residue **(E)**, and silverskin **(F)**.

Materials/Methods

Nutritional analysis by AOAC methods [2]

Hydro-ethanolic extracts

- Chlorogenic acids profile, caffeine, and 5-hydroxymethylfurfural (HMF) by RP-HPLC-DAD [1]
- Total phenolic content (TPC), total flavonoid contents (TFC), antioxidant activity (DDPH and FRAP) by spectrophotometry [3,4]

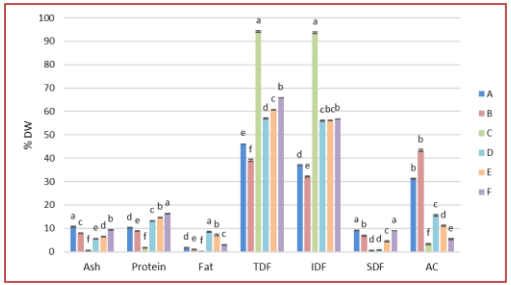

Figure 1. Nutritional composition of coffee by-products (% dw). Results are the average of 3 independent experiments ± SD. Different letters represent significant differences between samples ($p < 0.05$). TDF, total dietary fiber; IDF, insoluble dietary fiber; SDF, soluble dietary fiber; AC, available carbohydrates.

	A	B	C	D	E	F
TPC (CGAE)	2.37 ± 0.10 c	2.12 ± 0.02 c	0.18 ± 0.02 e	6.54 ± 0.24 a	5.11 ± 0.36 b	1.28 ± 0.01 d
TFC (CE)	1.23 ± 0.01 c	0.88 ± 0.02 d	0.08 ± 0.00 f	5.23 ± 0.10 a	4.91 ± 0.12 b	0.70 ± 0.01 e
FRAP (FSE)	8.58 ± 0.32 b	4.57 ± 0.21 c	0.35 ± 0.02 d	17.68 ± 0.33 a	17.56 ± 0.35 a	4.05 ± 0.12 c
DPPH•-SA (TE)	0.77 ± 0.10 b	0.29 ± 0.11 c	0.05 ± 0.00 d	3.11 ± 0.03 a	2.85 ± 0.18 a	0.19 ± 0.05 c

Table 1. Total phenolic compounds and in vitro antioxidant activity (DPPH• inhibition and FRAP assays) of coffee by-products (g/100 g dw). Results are the average of 3 independent experiments ± SD. In each line, different letters represent significant differences between samples ($p < 0.05$). CGAE, chlorogenic acid equivalents; CE, catechin equivalents; FRAP, ferric reducing antioxidant power; FSE, ferrous sulphate equivalents; DPPH•-SA, 2,2 diphenyl-1picrylhydrazyl radical scavenging activity; TE, Trolox equivalents.

Results/Discussion

All the analysed coffee by-products are rich in total dietary fiber (up to 94.19% dw for parchment **C**). Except parchment, all of them seem to be good sources of protein (up to 16.31% dw for silverskin **F**) with content comparable to other widely consumed foods such as quinoa (13.0%), buckwheat (14.8%), and millet (11.7%) [1].

	A	B	C	D	E	F
Caffeine	0.85± 0.02 c	0.46 ± 0.00 e	0.06 ± 0.00 f	1.40 ± 0.07 a	1.12 ± 0.01 b	0.71 ± 0.02 d
3-CQA	6.54 ± 0.14 c	4.01 ± 0.12 c	n.d.	408.20 ± 22.63 a	323.10 ± 5.42 b	9.44 ± 0.22 c
5-CQA	220.56 ± 6.99 c	83.93 ± 1.09 cd	5.36 ± 0.57 d	3787.58 ± 147.35 a	2533.06 ± 44.76 b	52.53 ± 0.83 cd
4-CQA	14.83 ± 1.05 c	11.82 ± 0.05 c	n.d.	684.96 ± 28.31 a	484.65 ± 6.34 b	17.71 ± 0.30 c
HMF	n.d.	n.d.	n.d.	n.d.	n.d.	39.52 ± 1.07

Table 2. Caffeine (g/100 g), caffeoylquinic acids (mg/100 g), and 5-hydroxymethylfurfural (mg/100 g) content of coffee by-products. Results are the average of 3 independent experiments ± SD. In each line, different superscript letters represent significant differences between samples ($p < 0.05$). CQA, caffeoylquinic acid.

Overall, all the samples are sources of caffeine and chlorogenic acids, especially 5-CQA. Silverskin **(F)** exhibited a HMF content of 39.5 mg/100 g dw resulting from the dehydration of sugars during roasting.

Defective beans **(D)** and sieving residue **(E)** can be highlighted for their high TPC and high antioxidant activity. The TPC of defective beans was about 30% lower than that reported for non-defective green coffee beans (9.42 g CGAE/100 g dw) [1]. In the FRAP assay, the pulp **(A)** exhibited nearly twice the reductive potential for ferric ions compared to husk **(B)**. The hydroethanolic extracts of coffee by-products can delay oxidative reactions through different mechanisms of action.

Conclusion/Perspectives

In conclusion, coffee by-products, from field to roasting, are rich sources of bioactive compounds, especially chlorogenic acids and caffeine. However, the differences found in the chemical quantitative profile and nutritional composition can broaden their potential applications. Future studies should focus on the effects of coffee by-products on human health, development of functional foods, and ensuring food security.

References: **1**. Machado, M. et al. 2023 Foods, 12, 2354; **2.** AOAC. 2019 Official Methods of Analysis of AOAC International, 21 st ed, USA; **3.** Alves, R. C. et al. 2010 J. Agric. Food Chem., 58, 12221–12229; **4.** Costa, A.S.G. et al. 2010 Ind. Crops Prod., 53, 350–357.

Funding: This work was funded by the project PTDC/SAU-NUT/2165/2021- COBY4HEALTH- Can coffee by-products decrease the risk of metabolic syndrome? A comprehensive approach to reduce waste and valorize health benefits, funded by FCT/MCTES, Portugal.
Acknowledgments: To FCT/MCTES for the projects UIDB/50006/2020 and UIDP/50006/2020; to the EU (FEDER funds through the NORTE2020 - ref. NORTE-01-0145-FEDER-000041); to JMV José Maria Vieira, SA, BICAFÉ Torrefação e Comércio de Café Lda., and Quinta do Avô João for provide the samples; M.M. thanks FCT/MCTES and ESF through NORTE 2020 for her PhD grant 2021.04907.BD. R.C.A. thanks FCT for funding through the Scientific Employment Stimulus - Individual Call (ref. CEECIND/01120/2017).