



LAQV
© REQUIMTE



5th International Conference on Sustainable
Solid Waste Management

VALORISATION OF SPENT COFFEE GROUNDS USING SUBCRITICAL WATER

Bruno Pedras, Susana Barreiros, Alexandre Paiva , Pedro Simões

Athens, 21st June 2017

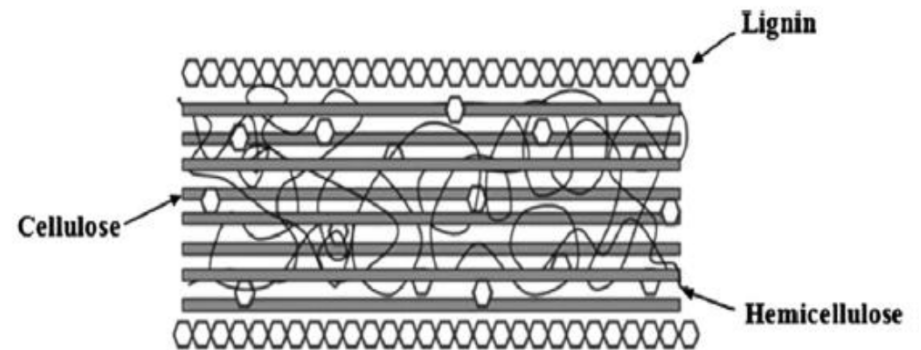


Spent Coffee Grounds (SCG)

- Coffee is one of the most consumed beverages in the world
- And the second most traded commodity in the world
- SCG is the by-product obtained in the preparation of instant coffee
- 6 million tons of this residue are generated worldwide every year
- SCG are usually discarded as solid waste

SCG potential

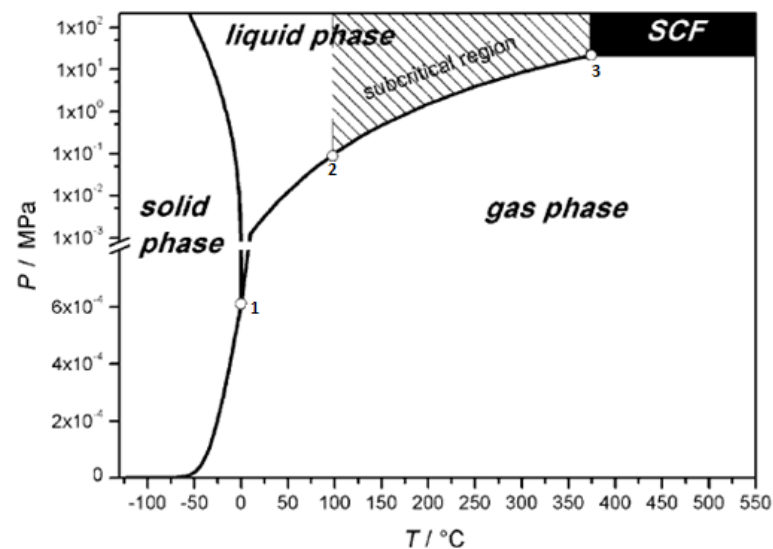
- Rich in lignocellulosic material:
 - Cellulose
 - Hemicellulose
 - Lignin
- Carbohydrates represents around 50%
 - Obtained usually by acidic hydrolysis
- Source of phenolic compounds
 - Extracted with organic solvents (methanol, ethanol, acetone)



Haghighi Mood, S. *et al. Renew. Sustain. Energy Rev.* **27**, 77–93 (2013)

Subcritical water (SBW)

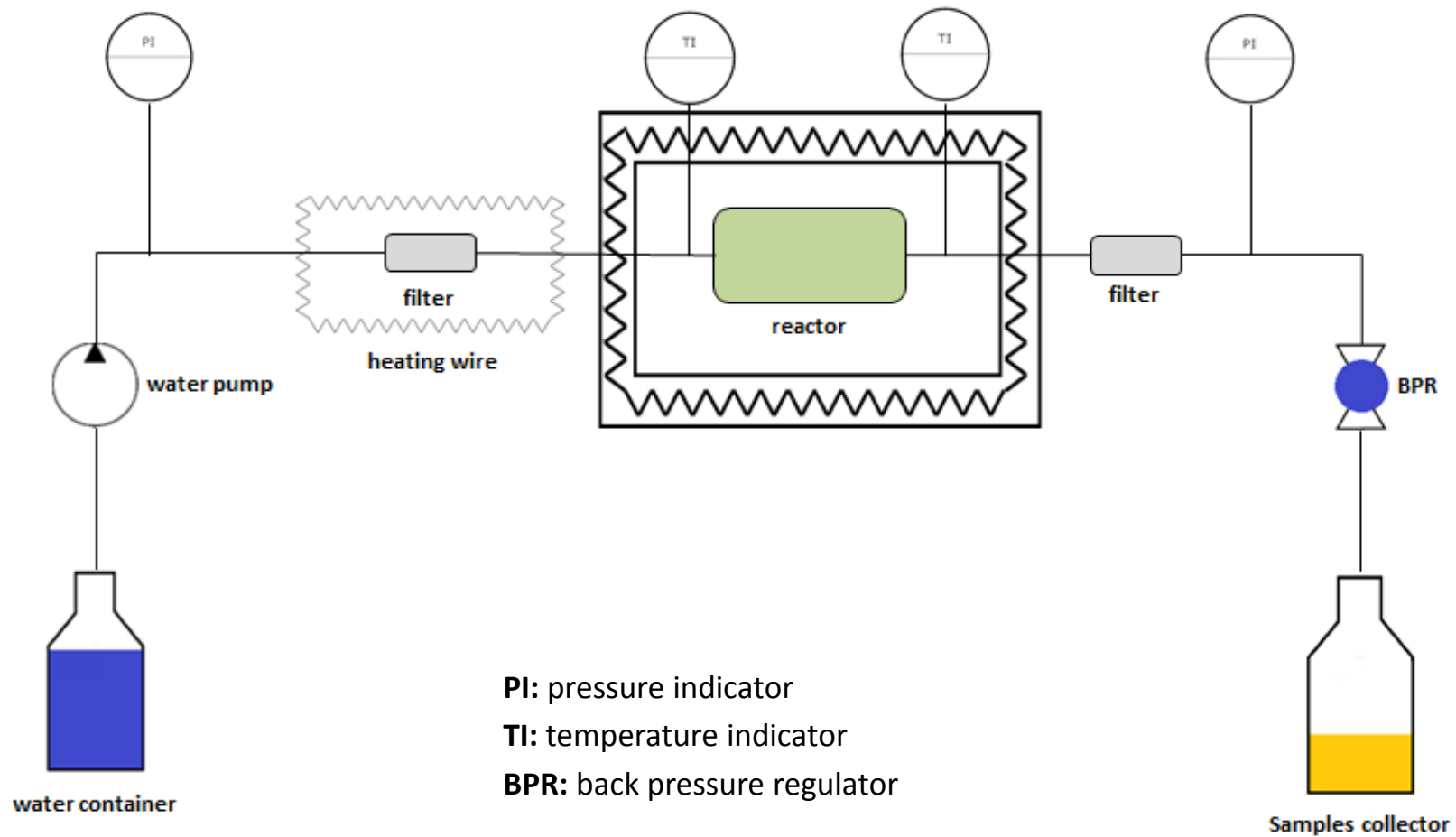
- Above 100°C and at pressures above vapor pressure
- Lower viscosity and surface tension
- Dielectric constant decreases (between 200 and 250 °C polarity is similar to methanol or ethanol)
- The ionic product is up to three orders of magnitude higher
- Behaves as acid or base catalyst
- It is a green solvent



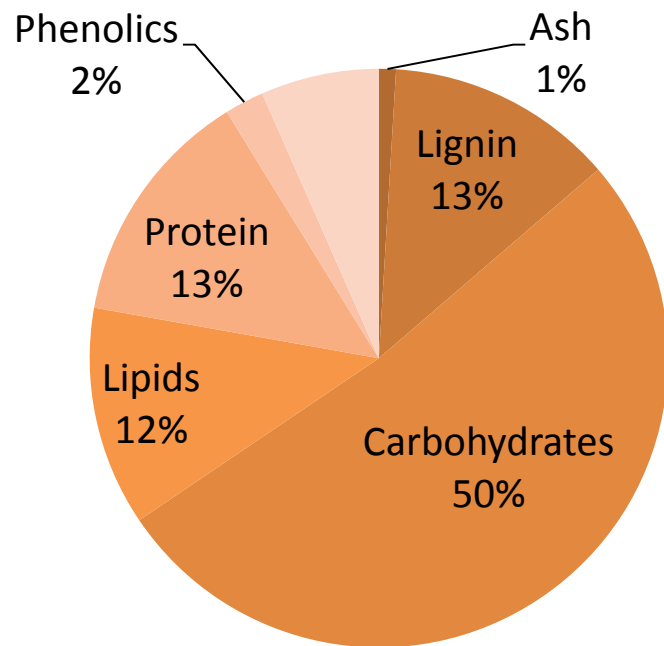
- 1- Triple point
- 2- Boiling point at ambient pressure
- 3- Critical point

Möller, M et al. ChemSusChem 4, 566–579 (2011).

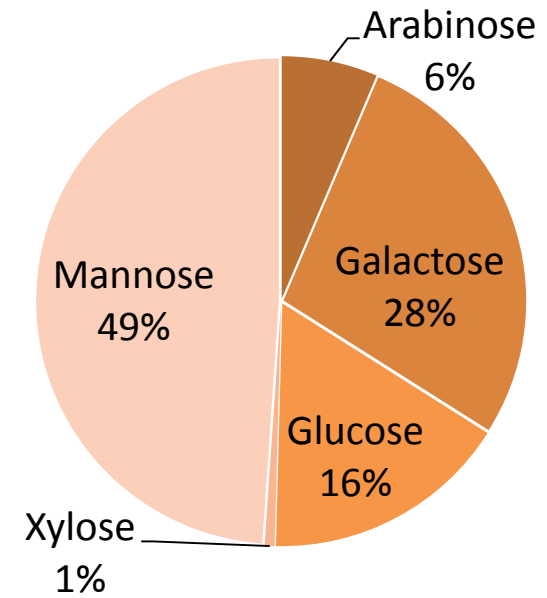
SBW semi-continuous apparatus



Chemical composition



8% cellulose
42% hemicellulose

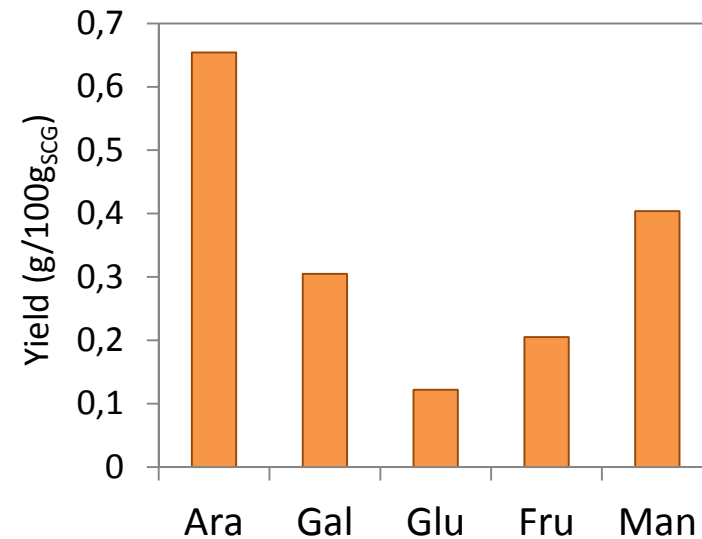
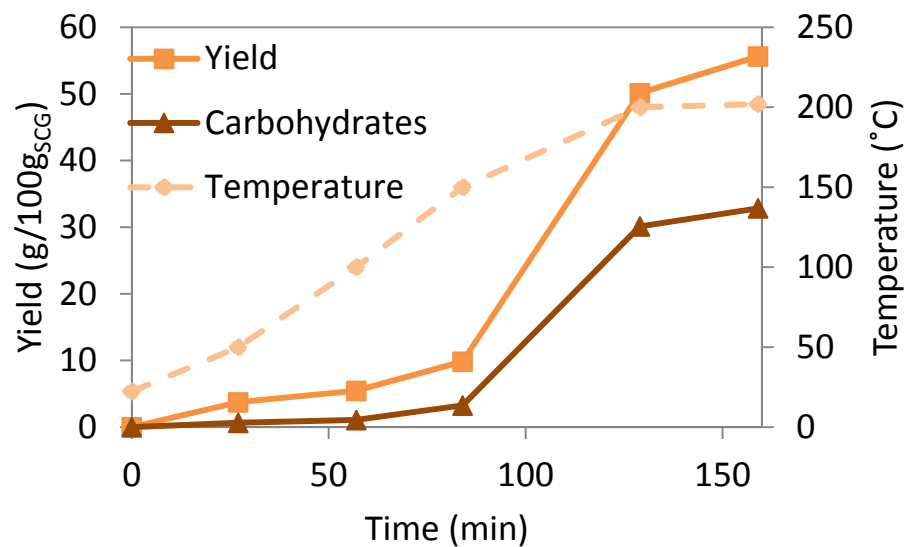


Efficiency of SBW extraction/hydrolysis

Temperature (°C)	Yield of SCG extract (g/100 g _{SCG})	Yield of carbohydrates (g/100 g _{SCG})	Yield of phenolics (g/100 g _{SCG})
water flow rate = 10 mL/min			
150	43	16.5	2.51
180	55	17.6	2.54
200	56	32.3	3.69
220	58	32.8	3.91
water flow rate = 5 mL/min			
150	32	8.8	1.68

- At 200 and 220 °C about 65% of the carbohydrates were recovered

Carbohydrates (200°C, 10 mL/min)



- Carbohydrates are recovered at higher temperatures
- Arabinose was the most abundant monosaccharide recovered
- The presence of fructose could be due to the Lobry de Bruyn–Alberda van Ekenstein transformation (LBET)

SCG extracts (200 °C, 10 mL/min)

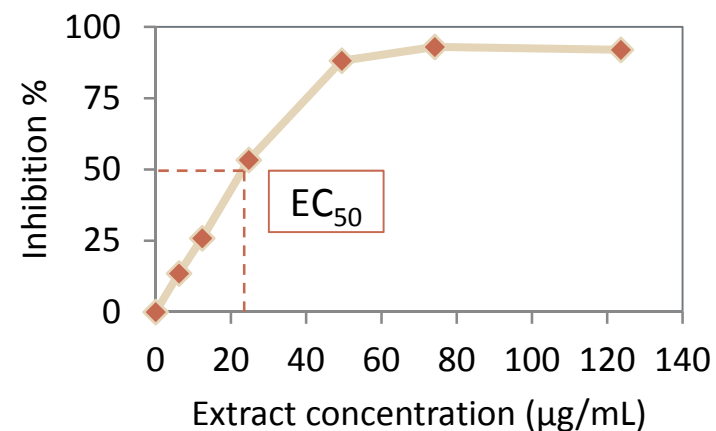
Extract sample	TPC (g/100g _{extract})	Carbohydrates (g/100g _{extract})
S1 (T up to 50 °C)	15.6	20.4
S2 (T: 50 – 100 °C)	16.6	24.6
S3 (T: 100 – 150 °C)	9.3	50.1
S4 (T: 150-200 °C)	5.4	66.7
S5 (T: 200 °C)	8.7	49.2

- Total phenolic content (TPC) is higher in extracts recovered at lower temperatures
- The extracts collected at higher temperatures are richer in carbohydrates

Phenolics and Antioxidant activity

- Antioxidant activity was evaluated by DPPH assay

Extract sample	EC ₅₀ ($\mu\text{g}/\text{mL}$)	TPC ($\text{g}/100\text{g}_{\text{extract}}$)
S1 (T up to 50 °C)	28.8	15.57
S2 (T: 50 – 100 °C)	23.3	16.58
S3 (T: 100 – 150 °C)	60.3	9.03
S4 (T: 150 – 200 °C)	80.9	5.35



- Antioxidant activity (AA) is higher in the phenolic-rich extracts (with a higher TPC)
- AA only around 10 times lower than ascorbic acid, EC₅₀ of **2.8 $\mu\text{g}/\text{mL}$**

Conclusions

- The highest recovery of carbohydrates and of phenolics was achieved in assays at 200 and 220 °C
- The use of a semi-continuous reactor conveniently allows the recovery of differentiated extracts
- At higher temperatures, above 150 °C, sugar-rich extracts were obtained, essentially from hydrolysis of hemicellulose
- Phenolic-rich extracts with a TPC of over 15 g/100g_{extract} and an high antioxidant activity were obtained at lower temperatures

Acknowledgments

This work was supported by the Associate Laboratory for Green Chemistry LAQV which is financed by national funds from FCT/MEC (**UID/QUI/50006/2013**) and co-financed by the ERDF under the PT2020 Partnership Agreement (**POCI-01-0145-FEDER - 007265**)

We acknowledge the help of Nuno Costa from Laboratório de Análises (LAQV, REQUIMTE).

Tank you for your attention!

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Cofinanciado por:

