Subcritical water extraction and identification of phenolic compounds from Brewer's Spent Grain (BSG)

Patricia Alonso-Riaño*, Esther Trigueros, María Teresa Sanz, Sagrario Beltrán, O. Benito-Román

University of Burgos, Biotechnology and Food Science Dept. Chemical Engineering Division

Pza. Misael Bañuelos s/n 09001 Burgos (Spain)

*Corresponding author: pariano@ubu.es

1. Introduction

Brewer's spent grain (BSG) is the most abundant brewing industry by-products, comprising 85 % of the total by products generated. BSG is mainly composed of carbohydrates (52%), lignin (18%), proteins (18%) and lipids (6%). BSG is also a valuable source of phenolic compounds, with approximately 1.2 % of mono- and di-meric phenolic acids, being hydroxycinnamic acids, such as ferulic and p-coumaric acids, the primary class of phenolic compounds that have demonstrated antioxidant effect. In this work, we proposed the use of subcritical water (SW) at 50 bar and 4 mL/min in a semi-continuous reactor at different temperatures, from 125 to 185 °C, to extract phenolic compounds from BSG.

2. Results and discussion

Total phenolic compounds (TPC) were determined according to the Folin-Ciocalteu assay. It was found that an increase in the operating temperature led to an increase in TPC with a maximum of accumulative TPC of 33.0 ± 0.3 mg GAE/$g_{dry\text{-}BSG}$ at 185 °C. Figure 1 shows the accumulative profile of individual phenolic compounds at different temperatures. Aldehyde phenolic compounds such as vanillin, syringic and protocatechuic aldehyde; reached the maximum level at the highest temperature studied in this work; however, for hydroxycinnamic acids, such as ferulic acid and p-coumaric, the maximum was obtained at 160 °C. The different behavior with temperature allowed fractionation of bioactive compounds by SW.

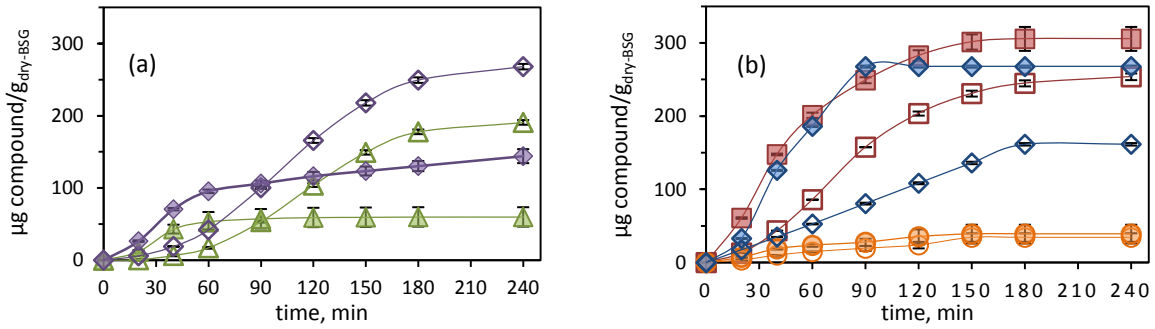

Figure 1. Accumulative individual phenolic compounds at 160 °C (open symbols) and 185 °C (filled symbols): (a) △ ▲ p-coumaric; ◇◆ferulic acid (b) □ ■ vanillin; ◇◆protocatechuic aldehyde; ○ ● Syringic aldehyde.

Reducing capacity of SW extracts, according to the FRAP assay, showed that increasing the temperature up to 185 °C significantly increased the reducing capacity ($p < 0.05$). A positive correlation between reducing capacity and total phenolic compounds was stablished according to the Pearson product moment correlation ($R^2 = 0.9511$). The high TPC value and antioxidant capacity of the extracts obtained at the highest temperatures could be due to newly formed compounds related to Maillard reactions that influence TPC and FRAP responses.

3. Conclusions

This study shows that phenolic compounds were successfully extracted from BSG using subcritical water. SW extraction of phenolic compounds was maximized at the highest temperature studied in this work, 185 °C, although hydroxycinnamic acids were more sensitive to temperature than aldehyde phenolic compounds. SW extracts showed a high antioxidant capacity and allowed extraction and fractionation of phenolic compounds.

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