Pressurized Water Extraction and Supercritical Water Hydrolysis as means to obtain Ferulic Acid from Wheat Bran

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Introduction

Phenolic compounds are of considerable interest due mainly to their antioxidant activity. They constitute a large family of compounds that can be found in cereals, fruits or vegetables, and present potential commercial applications in the food, health and cosmetic industries. By extracting them from waste materials, we are contributing not only to reduce but also to revalorize the residues.

Wheat bran is an abundant and underused byproduct from the milling industry, whose main phenolic compound is ferulic acid (FA). It can be found in three forms: soluble free (F-FA), soluble conjugated (C-FA) and insoluble bound form (B-FA), being the major part in the insoluble bound form, esterified to the arabinoxylans (AX) and other cell wall structural components (≈92%). Hence, new processes are required to break these bonds in order to recover it in high quantities.

In this study, two different techniques have been applied and compared with the aim of maximizing the extraction of FA from wheat bran: in the first one pressurized water (PW) is used as solvent and in the second one supercritical water (SCW) has been tested.

Results and discussion

The quantification of the initial content of FA in the wheat bran matrix was performed by an alkaline hydrolysis as described by Vaidyanathan et al. HPLC is used for quantification. Total FA, F-FA and C-FA were determined, and the obtained values were 2570.9±1.8, 3.8±0.2 and 31.6±0.1 μg/g respectively, all in dry basis.

Pressurized water has been used for the extraction in the range 120-180 ºC and times of 20-75 min. Experiments have been performed in a stirred tank extractor of 160 mL made of stainless steel. After the extraction time, the vessel is quickly quenched using an ice bath.

The extraction yield is evaluated with the content of FA in the solid before and after the extraction. The concentration of Total FA is evaluated in the aqueous extract and in the exhausted solid. A severity factor, R_0=t*exp((T-100)/14.75), was introduced to consider the simultaneous effect of temperature and time. The highest amount of extracted FA obtained was 381.6 µg/g of dry bran, obtained at 160ºC and 75 min, that corresponds to a log(R_0) ≈ 3.7. By applying higher severity factors, the amount of FA that is degraded turns to be higher than the amount that is being release. Quantification of FA revealed that 39% of FA remains in the solid, while 17% is present in its free form in the liquid and 8% in the soluble bound form, concluding that the rest must have been degraded. A degradation curve has shown that after 75 min, a solution of pure FA in water at 160ºC is degraded up to 80%.

Previous results indicate that the effect of temperature is to break the bonds between FA and AX, but if they are applied for a long time, the degradation is very high. In order to solve this problem, ultrafast hydrolysis with SCW at 400ºC and 250 bar was performed for 0.2 and 0.5 seconds, and lead to an amount of extracted FA of 800-1300 µg/g of dry bran, which is up to 3.5 times higher than the amounts obtained by PW extraction.

Conclusions

FA can be effectively extracted by using water as solvent with both techniques, PW and SCW. Taking into account the high degradation that occurs by applying high temperature during long times, ultrafast hydrolysis with SCW turns to be the best option, leading to amounts of extracted FA 3.5 times higher than with PW. Additionally, further experiments will be performed by using microwave assisted extraction, as it is also a technique that allows to obtain high temperatures in short times.

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