Microwaves and subcritical water for the process intensification of ferulic acid recovery from wheat bran

Wheat bran is an important by-product of the cereal milling industry and it has a great potential as raw material in a biorefinery. Wheat bran contains many important bioactive phenolic compounds, such as ferulic acid (FA), phytic acid, caffeic acid and flavonoids that can be recovered in a first step of a cereal biorefinery to increase economical benefit of the whole process. FA is the most abundant phenolic acid in the wheat bran, and it exhibits a number of potential applications such as natural antioxidant, food preservative/antimicrobial agent, anti-inflammatory agent, photoprotectant, and as precursor of vanillin (food flavor). FA seems to be part of the cell wall bounded via ester linkages to the structural polysaccharides, while dimers of ferulic acid can serve to cross-link hemicelluloses. Ferulic acid is unstable and can be oxidized in high temperature and it could be denature and reduced by using alkaline-hydrolysis. Release of FA from plant material is typically facilitated by alkaline and enzymatic hydrolysis. Alkaline-hydrolysis cannot be considered a green technology, is poorly selective and solvent consuming. Enzymatic-hydrolysis requires cocktails of enzymes (amylases, xylanases, proteases, feruloyl esterases) combined with bran pre-treatment and exhibits economical drawbacks and low extraction yield per unit of enzyme. The challenge is, therefore, to intensify the process by using green and short time techniques with high hydrolysis capacity to recover selectively the maximum amount of free FA and preserving the antioxidant activity of the extract.

In this work, we present and discuss a strategy to maximize the recovering of free FA from wheat bran by using microwaves and subcritical water. This study presents the effect of various factors in a Microwave-Assisted-Extraction (MAE) with water: time, temperature and solvent/solid ratio, using Box-Benhken experimental design. MAE of wheat bran at 220ºC and 1 minute leads to the recovery of ca. 80% of the FA, that is a really high yield compared to that reported in the literature for enzymatic hydrolysis (15-35%) [1]. However, more than 70% of FA remains bounded to the cell compounds extracted under such conditions. Subcritical water in the range has been evaluated to complete the release of free FA. Temperatures in the range 250-320 ºC and time from 1 to 10 min have been studied at 150 barg and discussed using the severity factor. Under such conditions dissociation of water is very important, and hydroxyl groups act to the ester bond breakage. Results are discussed in terms of total FA extraction yield, Free FA extraction yield, TOC and total phenolic content and antioxidant capacity of the final hydrolysate.

Reference:

1. Nishant Gopalan et al., Review on technological and scientific aspects of feruloyl esterases: A versatile enzyme for biorefining of biomass, Bioresource Technology 193 (2025): p. 534–544

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