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RÉGION WALLONNE

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Impact of pre-treatment processing on cereal by-products valorisation through enzymatic extraction of ferulic acid

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INTRODUCTION

The valorisation of biomass from agricultural origin takes part of a sustainable development approach. The fractionation (cracking) of these renewable resources supplies a variety of basic molecules which find applications in energy production, biomaterials formation or as chemical precursors of high-value compounds. There is a high interest in treating the biomass to extract sequentially as much as valorisable components as possible. In this approach, **enzymatic extraction provides an environmental friendly way** and allows further isolation of compounds by preserving the residue.

Amongst the molecules of interest that can be extracted from agricultural biomass, **ferulic acid shows potential commercial applications** in food (preservative agent, gel forming properties, flavour precursor), health (antioxidant, antimicrobial, anti-inflammatory…) and cosmetic (photoprotecting agent) industries. Ferulic acid is known to be abundant in cereals, where it constitutes a key molecule in the bran cell wall architecture. However, it is found to be esterified to constitutive polysaccharides (figs. 1-2), which form a network of highly branched ramifications thus hindering accessibility to degrading enzymes. Some **physical pre-treatments** were then investigated for their ability to ease the access to ferulic acid esterifying sites for a selection of enzymes.

FERULIC ACID (FA): esterified to constitutive arabinoxylans of aleurone cells

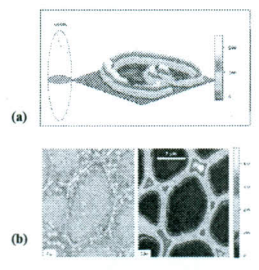


Fig 1. (a) Visualisation of FA in the envelope by auto-fluorescence and **(b)** conventional (left) and spectral (right) images showing FA auto-fluorescence at aleurone cell walls (Saadi A., Lempereur I., Sharanow S., Autran J. and Marfait M. 1998. Spatial distribution of phenolic materials in durum wheat grain as probed by confocal fluorescence spectral imaging. Journal of Cereal Science 28(2): 107-114).

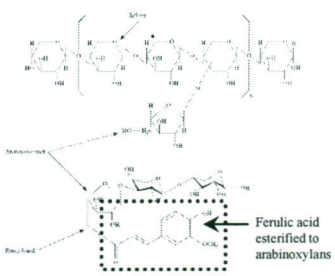


Fig 2. FA iesterified to arabinoxylans (AX) composing the cell walls of wheat bran (Piot O., Autran J.-C. and Marfait M. 2000. Spatial distribution of protein and phenolic constituents in wheat grain as probed by confocal Raman microspectroscopy. Journal of Cereal Science 32: 57-71).

ENZYMATIC EXTRACTION

[FA] TOTAL in wheat bran: ~ 0.6% (dw)

Determined by alkaline hydrolysis followed by HPLC analysis

SYNERGY of FAE with xylanase (fig. 3)

Xylanase: degrades AX in oligosaccharides

Ferulic acid esterase: degrades the ester bond between FA and AX

Synergy: esterified FA is more accessible to FAE when the polysaccharide is degraded by the xylanase :

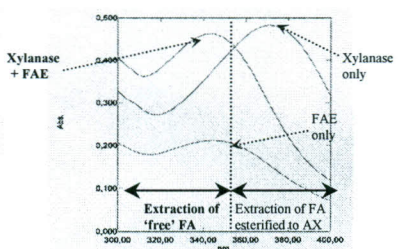


Fig 3. UV spectra of enzymatic extracts of wheat bran

ENZYMATIC EXTRACTION: conditions of incubation

Optimised after an experimental plant: 2h incubation at 60°C

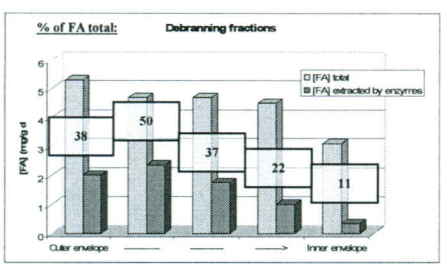
Ferulic acid esterase: 27 U g^{-1} (D686L™, Biocatalysts)

Xylanase: 110 U g^{-1} (Ref. 95595, Sigma-Aldrich)

Barberousse H., Kamoun A., Chaabouni C., Roiseux O., Deroanne C., Blecker C. Optimization of ferulic acid enzymatic extraction from wheat bran, an agro-industrial co-product, using response surface methodology. *under writing*.

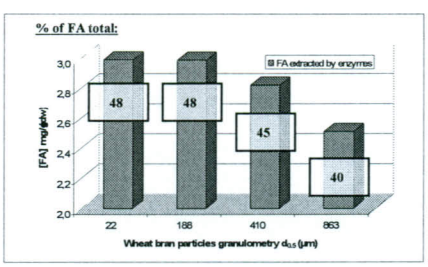
PRE-TREATMENTS

DEBRANNING: selection of wheat bran fractions of highest FA concentration



→ Debranning by sequential abrasion of whole grains: isolation of bran fractions containing aleurone cells, rich in ferulic acid and enhancement of FA enzymatic extraction

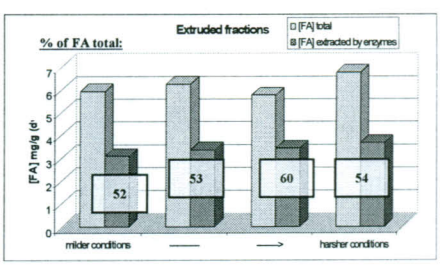
MICRONISATION: fine granulometry favours FA enzymatic extraction



→ Granulometries of wheat bran particles below 200 µm ($d_{0.5}$) seem to favour higher FA extraction rates.

→ Micronisation techniques such as ball milling, jet milling and high-pressure micronisation are of special interest, as they allow treating large quantities of material to reduce particle sizes to microscale.

EXTRUSION-COOKING: high temperature and shear treatment enhance FA extraction



→ Harsher conditions of temperature and shear enhance the rate of FA to be extracted by way of enzymes.

→ Extrusion of wheat bran enhances the splitting of fibres linkages and increases the solubility of hemicelluloses (arabinoxylans here), thus accessibility to enzymes.

PERSPECTIVES

Combine different pre-treatments to optimise FA extraction

Investigate the techno functional properties of the extracted FA

Characterise the co-products of enzymatic extraction for valorisation