Enzymatic process development for the extraction of ferulic acid from wheat bran

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The agro-industries generate each year thousands of tons of by-products, such as cereal bran or sugar beet pulps. For instance, Walloon wheat transformation industry provides annually about 200,000 tons of bran. Most of those by-products are under-valORIZED as cattle feed. By the use of biorefinery, this biomass may constitute a renewable source for various value-added molecules like dietary fibres, proteins, antioxidants, and more.

A thesis in progress in the Food Science and formulation laboratory of Gembloux Agro-Bio Tech focuses on the bio-extraction of ferulic acid

What is ferulic acid?

Ferulic Acid (FA) is the main example of the hydroxycinnamic acids part of the phenolic acids family

FA is a powerful antioxidant as it is a strong H donor stabilized by resonance

FA is present in wheat bran about 5 mg/g, dry basis, mainly ester-linked to the constitutive arabinoxylans (AX).

Enzymatic hydrolysis of ferulic acid is the result of a synergistic action of several AX-degrading enzymes, mainly xylanases (hemicellulases) and ferulic acid esterases.

Other enzymes (cellulases, proteases) may help to crack the complex cell-wall structure.

Occurrence

Comparison of the antioxidant activities of FA and Trolox measured by several methods i.e. by the scavenging of several radicals.

DPPH (1,1-diphenyl-2-picrylhydrazyl), AAPH (peroxyl radical), OH (hydroxyl radical), CLO (hypochlorite ion), ONOO (peroxynitrite).

FA is a powerful antioxidant as it is a strong H donor stabilized by resonance

Structural units of arabinoxylan, showing main constitutive elements (substitution of the xylan backbone) and hydrolysing enzymes.

Extraction process: in development

The aim of the thesis is to study a process, starting from raw wheat bran to obtain purified ferulic acid, either crystalized or in concentrated solution. Furthermore, this process should be feasible at pilot scale, as it is meant to commercial application.

Pretreatment

Wheat bran

Physical processing used to facilitate the access of the enzyme to the AX by reducing the size of the particles (grinding, micronisation), to concentrate the FA-containing fraction (dextraching, fiber extraction), to isolate richer layers of the bran (debranning), or to crack cell-walls (extrusion, steam-explosion)

Enzymatic hydrolysis

The enzymatic hydrolysis breaks the ester links that bound ferulic acid molecules to AX. Released AF is solubilised in the acid form.

Hydrolysate

Contains solubilised FA, proteins, oligomeric sugars, etc.

Enzymatic hydrolysis

Parameters: temperature, stirring, water/bran ratio, enzyme load... Impact on reaction kinetic, FA recovery...

Bioreactor design

Removal of press filtration or centrifugation. Still rich in dietary fiber, proteins or other compounds of interest (possible valorization)

Hydrolysate

Purification

Involves further removal of non-FA compounds (ultrafiltration), concentration of FA solution (steam extraction, reverse osmosis) and/or selective adsorption on polymeric resins

Purified ferulic acid

Applications include food antioxidant, dietary complement, aroma precursor (vanillin or coniferyl alcohol)...

Pretreatment

Wheat bran

FA content may vary (analysis by alkaline hydrolysis)

Treated wheat bran

cOmmercial enzyme complexes

With FAE activity: Ex: Biocatalysts Depol™ 740L (FAE 36 U/g)
Novozymes Pentopan™ 500 BG Catalysts Pectinase™ PE
Danisco Grindamyl™ S100

Residual bran

Removed by press filtration or centrifugation. Still rich in dietary fiber, proteins or other compounds of interest (possible valorization)