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Extraction and bioconversion of kaempferol metabolites from cauliflower outer leaves through fungal fermentation

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ABSTRACT

Cauliflower outer leaves contain bioactive compounds, therefore fermentation could be a strategy to release phenolic compounds and their metabolites and thus increase their valorization potential. This study aimed to evaluate the release and metabolism of different filamentous fungi. The fermentation with *Aspergillus sojae* was found to extract the highest level of total phenolic compounds (321 mg rutin equivalents (RE)/100 g fresh weight (FW)) after 1 day, which was 3 times higher compared to the unfermented sample (113 mg RE/100 g FW). The most dominant kaempferol metabolites were kaempferol-3-*O*-diglucoside in all fermented samples (38–126 mg RE/100 g FW) and kaempferol-3-*O*-diglucoside-7-*O*-glucoside in the unfermented sample (34.8 mg RE/100 g FW). Furthermore, in all fungal treated samples, the phenolic profile shifted to a profile with less or no carbohydrate moieties at the 3- or 7-carbon position. These results indicate the potential of solid-state fermentation to obtain different phenolic-rich extracts, with a unique profile in phenolic compounds, depending on the fungal strain used.

1. Introduction

The non-edible parts of cauliflower (*Brassica oleracea* L. var. *botrytis*), consisting of outer leaves, stems and pods, are important by-products from the cauliflower harvest. These residues still contain high amounts of bioactives e.g., phenolic compounds, vitamins, that are known for their bioactivities, such as the potential prevention of health risks as cardiovascular diseases, obesity, diabetes and cancer [1–3]. Therefore, the recovery of bioactive compounds from the cauliflower waste streams could contribute to a high-value valorization process, instead of its current use in fiber production [4], animal feed [5] or left on the fields.

The majority of phenolic compounds produced by plants are present in a bound form to cell walls in which they are conjugated with polysaccharides, organic acids and proteins [6–9]. Thus, the application of a hydrolysis process prior to conventional solvent extraction could be promising to maximize the extraction yield. Often chemical pretreatments such as acidic or alkaline hydrolysis, are used. However, these techniques cause several drawbacks, e.g., thermal degradation of phenolic compounds and safety hazards of final products [10,11]. Another technique to depolymerize cell-wall polysaccharides is based on the use of cell-wall degrading enzymes to break down the cell wall matrix, resulting in the release of bound phenolic compounds [6–8,11–14]. However, the main limitation for the application of enzymes has been their high cost [15].

Currently, microbial fermentation has been shown to be an alternative process to improve the release, stability, as well as bioavailability of phenolic compounds. The mechanism is based on the degradation of the cell-wall matrix and the bioconversion of released compounds by the system of carbohydrate-cleaving enzymes produced by fungi or bacteria during fermentation [9,16,17]. Moreover, through fermentation several filamentous fungi have been found to be capable of producing these carbohydrate-cleaving enzymes such as β-glucosidase [9] which can be effective in catalyzing the hydrolysis of glycosidic linkages of aryl- or alkyl-β-glucoside and cellobiose [18]. As a result of this, phenolic glycosides can be converted to aglycones having a higher antioxidant activity [19] as well as bioavailability [20]. Besides β-glucosidases, fungi are well-known for their production in cell-wall degrading enzymes, such as cellulases, hemicellulases and lignin-degrading enzymes [21].

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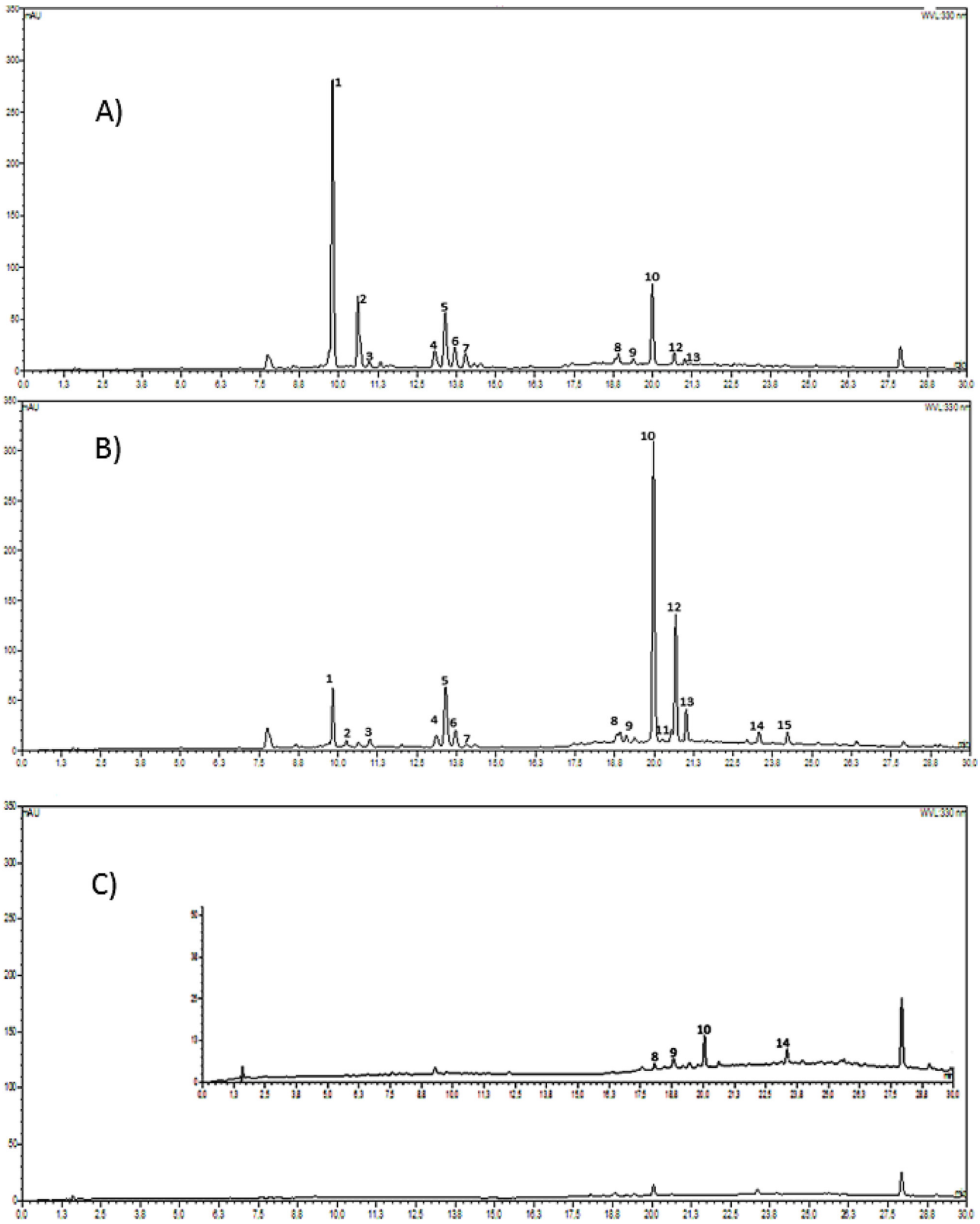

Fig. 1. UPLC profile of phenolic compounds from cauliflower outer leaves unfermented (A), or fermented with *Aspergillus sojae* for 1 day (B) and 7 days (C), recorded at 330 nm (see Table 1 for identification of peaks).

Extracting the bioactive compounds from plant products using a microbial fermentation process has been reported before, e.g., with apple pomace [9], black soybeans [22] and *Larrea tridentate* leaves [23]. In addition, bioconversion of the phenolic glycosides into their aglycones has also been shown in recent studies, mainly focusing on fermentation with filamentous fungi such as bioconversion of isoflavones from soybean by *Aspergillus oryzae* [24], *Rhizopus* spp.