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Improving phenolic compositions and bioactivity of oats by enzymatic hydrolysis and microbial fermentation

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ABSTRACT

In the present study, oats were successively hydrolysed by cellulase and fermented with *Monascus anka*, and the phenolic profiles, antioxidant activities and enzyme inhibition activities of the soluble and insoluble phenolic fractions were investigated. The results revealed that the cellulase could release great quantities of insoluble phenolics from oats. Compared to the traditional fermentation system, the system of fermentation following enzymatic hydrolysis (FEH) further increased the soluble and insoluble phenolic contents (24.38% and 31.05%, respectively). The contents of gallic, chlorogenic and ferulic acid in the soluble fraction increased by 42.49%, 85.79% and 46.42%, respectively. Both soluble and insoluble phenolic fractions from the FEH system showed great DPPH and $ABTS^+$ radical scavenging abilities. Moreover, the soluble phenolic fraction exhibited significantly ($p < 0.05$) higher α-glucosidase inhibition, while the insoluble phenolic fraction had significantly ($p < 0.05$) higher α-amylase inhibitory activity. This research could provide guidance for a new processing technique for oats rich in phenolics.

1. Introduction

Phenolic compounds are important secondary metabolites in plants that contain benzene rings with one or more hydroxyl substituents, and range from simple phenolic molecules to highly polymerized compounds (Randhir, Lin, & Shetty, 2004; Velderrain-Rodríguez et al., 2014). Phenolic compounds have many advantages such as anti-ageing, anti-inflammatory, antioxidant and antiproliferative activities (Lin et al., 2016). Many studies have reported that phenolic compounds in oats are some of the most important natural antioxidants (Bei, Liu, Wang, Chen, & Wu, 2017; Cai et al., 2011; Hitayezu, Baakdah, Kinnin, Henderson, & Tsopmo, 2015; Tong et al., 2014). Moreover, phenolic compounds can modulate carbohydrate and lipid metabolism to attenuate hyperglycemia, dyslipidemia and insulin resistance (Lin et al., 2016). However, the most common phenolic compounds, simple phenolic acids and flavonoids, generally occur as insoluble forms (Acosta-Estrada, Gutiérrez-Uribe, & Serna-Saldívar, 2014). Enzymatic hydrolysis is a specific and effective method to release bound phenolic acids from cell wall materials, including oats (Chen, Shi, & Hu, 2016). Cell-wall-hydrolysing enzymes, such as cellulases, amylase, hemicellulases and pectinase, have been effectively used to release bound phenolics (Acosta-Estrada et al., 2014; Kim et al., 2005; Zheng, Hwang, & Chung, 2009).

Solid-state fermentation (SSF) has been successfully used to convert agro-industrial residues and plant materials, into variety of valuable compounds, including bioactive phenolic compounds (Liu et al., 2017; Martins et al., 2011). Sequential enzymatic hydrolysis and fermentation are widely used in bio-ethanol production (Öhgren, Bura, Lesnicki, Saddler, & Zacchi, 2007). Our previous study finds that *Monascus anka* can grow well in a substance composed of oats. And the fermentation process can significantly increase the total phenolic contents in oats, especially the soluble phenolic content (Bei et al., 2017). Moreover, we found out that there were good correlations between phenolic contents and α-amylase, xylanase and cellulase activities. However, the cellulase activity was relatively low in the *Monascus* fermentation system, which may lead to the insoluble phenolics cannot fully released (Bei, Chen, Lu, Wu, & Wu, 2018). To further increase the phenolic content and bioactivity of oats, it is desirable to enzymatically degrade the cell walls of oats to release phenolics. Furthermore, the combination of enzymatic hydrolysis and fermentation in oats has not been studied.

This research aimed to evaluate the potential to release insoluble phenolics in oat by cellulase pretreatment. Moreover, we combined the enzymatic hydrolysis and fermentation in oats to investigate the co-effect of enzymatic hydrolysis and fermentation on oat phenolic

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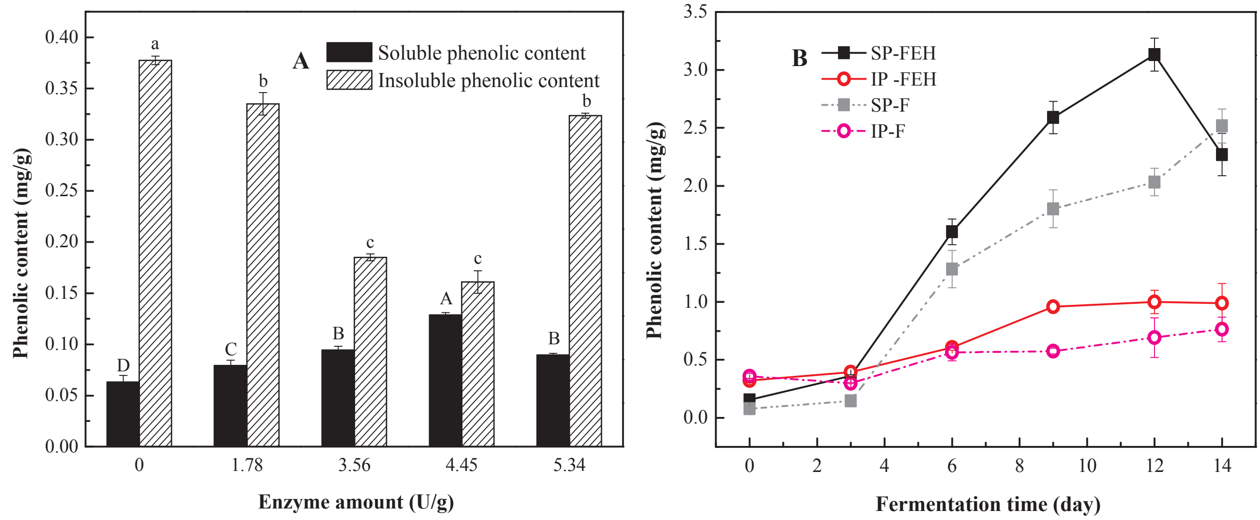

Fig. 1. Soluble and insoluble phenolic contents of (A) cellulase treatment, and (B) fermentation following enzymatic hydrolysis and fermentation. SP-FEH, soluble phenolics in fermentation following enzymatic hydrolysis; IP-FEH, insoluble phenolics in fermentation following enzymatic hydrolysis; SP-F, soluble phenolics in fermentation; IP-F, insoluble phenolics in fermentation.

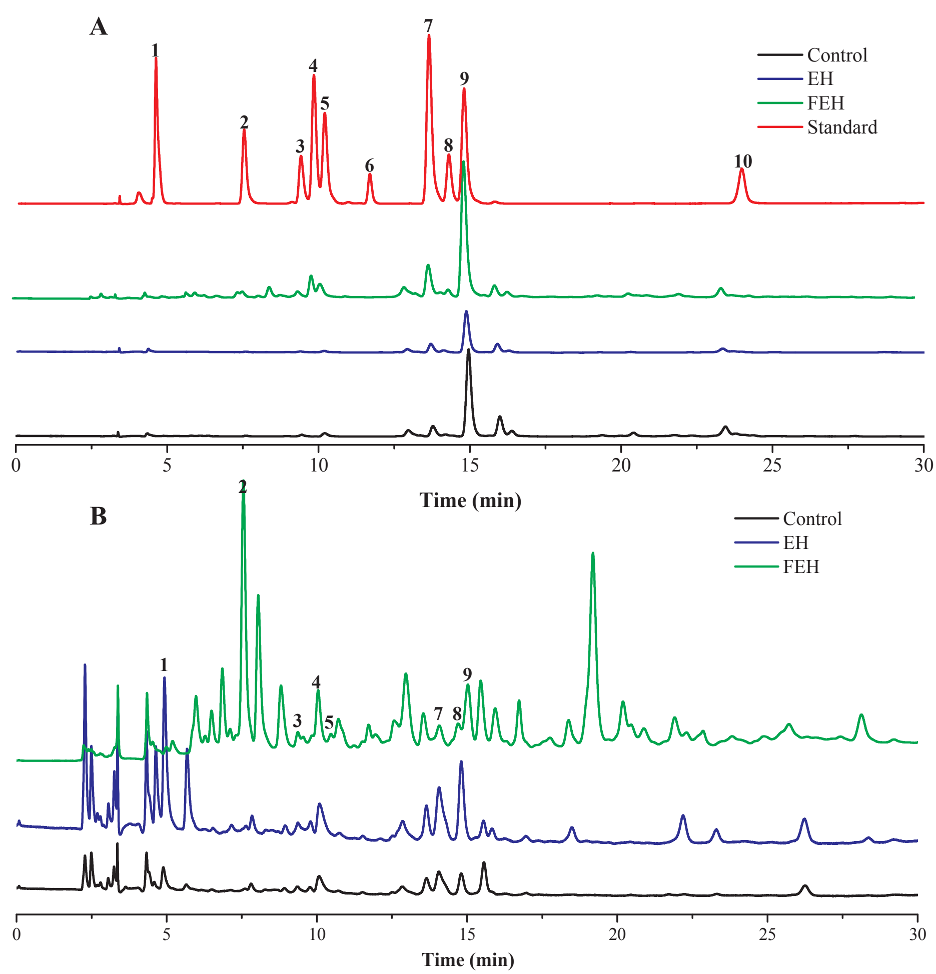

Fig. 2. HPLC chromatograms of (A) mixture of 10 investigated standards and insoluble phenolics in oats from different systems, and (B) soluble phenolics in oats from different systems using diode array detector at 280 nm: 1, gallic acid; 2, chlorogenic acid; 3, *p*-hydroxybenzoic acid; 4, caffeic acid; 5, vanillic acid; 6, rutin; 7, *p*-coumaric acid; 8, sinapic acid; 9, ferulic acid; and 10, quercetin.