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Pilot-scale ohmic heating-assisted extraction of wheat bran bioactive compounds: Effects of the extract on corn oil stability

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ABSTRACT

Recent studies introduced ohmic heating-assisted extraction (OHAE) as a promising emerging technology at laboratory-scales. The objectives of the present study were, first, to investigate the applicability of OHAE at pilot-scale for extraction of bioactive compounds from wheat bran immersed in a polar solvent (salted water containing 0.1% NaCl) at the electric field strengths (EFS) of 4.28, 7.90, and 15.71 V/cm and, second, to evaluate the effects of the wheat extracts on the corn oil stability during 30 days of storage at 45 °C. The results showed that OHAE saved 63% of energy consumption compared with the conventional extraction method. Also, the scaled-up OHAE unit yielded extracts with high quantities of bioactive compounds (110–460 ppm total phenolics) and higher antioxidant activities (antioxidant effectiveness of 56–84%) than those of the extract obtained through the conventional extraction method, i.e., 95 ppm total phenolics with antioxidant effectiveness of 51%. Increasing the EFS increased total phenolics and antioxidant effectiveness of extracts. The incorporation of 250 ppm of the extract obtained at the highest EFS effectively postponed the oxidation of corn oil during one month of storage (peroxide value of 7 vs. 19 meq/kg compared with the control sample) and extended the half-life of oil from 11 to 26 days. Besides, mathematical models proposed in this study well-predicted the oxidation stability of the oil samples mixed with the extract.

1. Introduction

Wheat is one of the common grains used in preparing flour to produce various foods. Wheat bran accounts for about a quarter of the by-product of the milling industry, with an approximate annual generation rate of 150,000 tons (Cardenia et al., 2018; Prückler et al., 2014). The issue of such a huge biomass production is usually addressed by the bioethanol and farming industries due to the relatively low-cost of this by-product (Cardenia et al., 2018; Gavahian, Munekata, et al., 2019). This by-product also has a good potential for valorization through the extraction process as it contains several polar bioactive compounds (e.g. about 20 μg/g benzoic acid, 16 μg/g vanillic acid, 57 μg/g syringic acid, 130–162 μg/g p-coumaric acid, 115–276 μg/g sinapic acid, 4610–5670 μg/g ferulic acid, and 780–1550 μg/g ferulic acid dimers) that have the potential of being used as a natural antioxidant for extending the shelf-life of edible oils such as corn oil which is a unique source of essential fatty acids with a limited shelf-life (Barrera-Arellano et al., 2019; Brouns, Hemery, Price, & Anson, 2012; López-Perea et al., 2019; Shahid Chatha, Hussain, Bajwa, Hussain Sherazi, & Shaukat, 2011). Such information attracted the attention of academia and industry. However, conventional extraction techniques did not provide an efficient platform for wheat bran valorization due to their limitations such as using chemical solvents that could be toxic, long process time, low efficiency, and high energy consumption which is not environmentally friendly (Gavahian, Chu, & Mousavi Khaneghah, 2019). Hence, emerging technologies, such as ohmic heating, might be a potential solution to provide alternative valorization techniques according to the promising results obtained at laboratory-scales (Gavahian, Chu, & Sastry, 2018; Gavahian, Farahnaky, Shavezipur, & Sastry, 2016; Gavahian & Farahnaky, 2018; Pereira et al., 2016).

Ohmic heating involves volumetrically heating of an electro-conductive mixture through the passage of electrical current (Gavahian & Tiwari, 2020). The heat generated by ohmic heating can be used to recover target components, that is, the ohmic heating-assisted extraction (OHAE) process (Gavahian, Lee, & Chu, 2018; Gavahian, Sastry, Farhoosh, & Farahnaky, 2020). This extraction technique has been applied to various herbs (Gavahian, Sastry, Farhoosh, & Farahnaky, 2020), tomato waste (Coelho, Pereira, Rodrigues, Teixeira, & Pintado,

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