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FULL PAPER

Optimization of tocols and γ-oryzanol extraction from rice bran using ultrasound and soybean oil as a green solvent

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Abstract

A new process was developed to extract tocols and γ-oryzanol from rice bran using ultrasound with soybean oil as a natural solvent. Results were compared to the conventional solvent method. The extraction process was optimized using response surface methodology (RSM) with three independent process variables as amplitude level (A) (20-60%), extraction temperature (B) (25-65°C) and time (C) (20-60 mins). Statistical analysis indicated that models developed for all responses were significant. Linear terms of all process variables had significant effects on α-tocopherol, γ-tocopherol, and γ-oryzanol, while quadratic effects of amplitude level (A^2), temperature (B^2) and time (C^2) on all responses were highly significant. Optimal process conditions for maximum yield of tocopherols and γ-oryzanol were 40% amplitude level, 65°C solution temperature and 40 mins. Yields of α-tocopherol and γ-oryzanol in oil extracted under the optimal conditions or ultrasound-assisted soybean oil extraction (O-UASO) were comparable to oil yield produced by conventional solvent extraction (O-CSE). Interestingly, O-UASO showed higher total antioxidant activities compared with O-CSE. Extraction using ultrasound with soybean oil was proposed as an effective alternative green process to improve oil functionality without the need for separating environmentally hazardous organic solvents.

1. Introduction

Rice (*Oryza sativa* L.) is a staple food crop for more than half of the global population and is consumed by over 90% of people in Asia, especially Southeast Asia (Thailand), China, and India (FAO, 2016). Before consumption or serving as an ingredient in food products, rice is generally milled and/or polished and 8-10% of the outer grain layer is removed as rice bran (Loypimai *et al*., 2009). Previous studies (Loypimai *et al*., 2009; Loypimai *et al*., 2015) reported that the rice bran fraction contained highly valuable bioactive components such as tocols (tocopherols and tocotrienols), γ-oryzanol and phenolic compounds. These compounds are now generating interest because of their potential beneficial effects on human health and improving food storage stability. Nevertheless, a large amount of rice bran is not efficiently utilized and is mainly used as a feedstock instead of realizing its potential as a functional food ingredient and as a productive source of healthy rice bran oil.

Traditionally, conventional extraction methods with organic solvents such as methanol and hexane have been used to recover these valuable compounds from rice bran (Loypimai *et al*., 2009; Loypimai *et al*., 2016). Currently, the use of these solvents in the food industry presents some disadvantages including their flammable, volatile, and toxic nature, and subsequent environmental pollution (Balachandran *et al*., 2008). Therefore, safer extraction methods with improved environmental and economic aspects have recently gained interest in the food industry (Chemat *et al*., 2012). Extraction using edible vegetable oils is a green process to produce natural products, while environmentally friendly solvents reduce energy consumption and produce non-denatured extract without contaminants (Chemat *et al*., 2012). In addition, the oil is used as a barrier to prevent the attraction of oxygen molecules and, consequently, retard oxidation and degradation rates of the carotenoid extracts (Pu *et al*., 2010). However, high oil viscosity is a major problem which results in low diffusivity and low

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