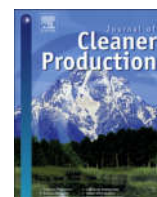




Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Enhanced extraction and preconcentration of main target saponins from *Panax notoginseng* root using green and efficient formulated surfactant aqueous systems

Qi Cui ^{a,1}, Juzhao Liu ^{a,1}, Wenjing Xu ^a, Yu-Fei Kang ^a, Xinyu Wang ^a, Yanyan Li ^a, Yujie Fu ^{a,b,*}

^a Key Laboratory of Forest Plant Ecology, Ministry of Education, Northeast Forestry University, Harbin 150040, PR China

^b Advanced Innovation Center for Tree Breeding by Molecular Design, Beijing Forestry University, 100083 Beijing, China

ARTICLE INFO

Article history:

Received 12 June 2018

Received in revised form

17 October 2018

Accepted 15 November 2018

Available online 17 November 2018

Keywords:

Formulated surfactant

Ultrasonic-assisted technology

Saponins

Panax notoginseng root

HPLC analysis

ABSTRACT

In this study, the formulated surfactant aqueous system composed of 2% (w/v) Triton X-114 and 0.03% (w/v) Gemini 16-5-16 coupled with ultrasonic-assisted technology has been selected as an effective method for the extraction and preconcentration of five main saponin compounds in *Panax notoginseng* root samples. Under the optimum parameters, the extraction yields of notoginsenoside R₁, ginsenosides Rg₁, Re, Rb₁ and Rd could reach the values of 28.66 mg/g, 46.52 mg/g, 12.91 mg/g, 29.31 mg/g and 9.26 mg/g, respectively. And the preconcentration factor could be 11.5-fold. In addition, the proposed formulated surfactant system is also suitable for the subsequent HPLC analysis with excellent linearity correlation coefficient $R^2 \geq 0.99$, high repeatability with relative standard deviation (RSD) of less than 4.45% and good recoveries within 97.12%–101.28%. Thus, the method gave higher extraction efficiencies, higher enhancement factors as well as excellent chromatographic performance than conventional solvents for the studied five main saponins in *Panax notoginseng*. In addition, the green and environmentally friendly formulated surfactant aqueous system which endows the safety and reliability of the extraction and preconcentration process. Moreover, this work is a one-step sample preparation procedure that integrated of extraction and preconcentration of target constituents. And the results indicated that the developed method possess the potential to large-scale extract and purify the bioactive components from plant materials.

© 2018 Elsevier Ltd. All rights reserved.

1. Introduction

Panax notoginseng (Burk.) F.H. Chen is a well-known and valuable Chinese medicinal plant. It has been used in Chinese medical practice for centuries (Zhao et al., 2006). The root parts of *Panax notoginseng* is commonly considered as medicinal part, which have been used for treatment of hematological and cardiovascular diseases (Chan et al., 2003). It has extensive bioactivities, such as hepatoprotective, cardioprotective, antioxidant and antidepressant activities (Dong et al., 2003; Liu et al., 2009; Yoshikawa et al., 2003). And its prominent activities could largely be attributed to

drammarane triterpenoid saponins, including 20(S)-protopanaxatriol-type and 20(S)-protopanaxadiol-type saponins (Lee et al., 2017). Notoginsenoside R₁, ginsenosides Rg₁, Re, Rb₁ and Rd are considered as five main saponins in *Panax notoginseng* (Wang et al., 2017a, b). Thus, it is of great significance to develop a fast and green technology to extract and monitor them from *Panax notoginseng*. Previously, many normal extraction techniques including liquid-liquid extraction, solid-phase extraction and supercritical fluid extraction have been employed for the extraction of bioactive components from different plants (Li et al., 2017; Long et al., 2016; Dong et al., 2016). However, these methods require large amount of organic solvents or special equipment, which are not feasible for routine analysis (Chan et al., 2011; Heng et al., 2013). Therefore, there is an effective need to develop an efficient and target compounds-oriented extraction and enrichment technologies, preferentially operating at a mild condition.

According to the previous studies, surfactant extraction is a

* Corresponding author. Key Laboratory of Forest Plant Ecology, Ministry of Education, Northeast Forestry University, Harbin 150040, PR China.

E-mail address: yujie_fu@163.com (Y. Fu).

¹ These authors contributed equally to this work.