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An integrated strategy for extraction and pre-concentration of four astragalosides from *Radix Astragali* by a formulated surfactant aqueous system

Suixin Wang[a,1], Jiao Jiao[a,1], Xinyu Wang[a], Qingyan Gai[a], Ping Kou[a], Wenjing Xu[a], Meng Luo[a], Chunjian Zhao[a], Yu-Jie 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, PR China

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ABSTRACT

Integrated and environmentally friendly methods for extraction and enrichment of natural products have gained increasing interests. The proposed preparation process provides the possibility that extraction and pre-concentration for astragalosides from *Radix Astragali* roots can be conducted with the surfactant aqueous system in one single procedure. The formulated surfactant system composing of 2% TX-114 as surfactant and 0.03% (w/v) of Gemini 16-5-16 as co-surfactant showed higher extraction efficiency with ultrasonic-assisted method and four astragalosides could be enriched by the cloud point phenomenon of surfactant. This work represents a valuable alternative for the eco-friendly extraction and enrichment of secondary metabolites from plants.

Introduction

The dried root of *Astragalus membranaceus* (Fisch.) Bunge. or *A. membranaceus* var. *mongholicus* (Bunge.) Hsiao is named as *Radix Astragali* (Huangqi in Chinese), which is a traditional and famous herbal medicine and nutritional product [1]. It could also be used in cooking as an additive. It has a history of over 2000 years in China and attracts attention in biological activity study. The *R. Astragali* has been proven that it possesses extensive bioactivities, such as immunomodulation [2,3], antioxidation [4–6], anti-inflammation [7,8], anti-cancer [9,10], enhancing hematopoietic function [11] and cardiovascular function [12,13]. These bioactivities are associated with the chemical constituents including astragalosides, isoflavonoids, polysaccharides, amino butyric acids and various trace elements [14,15]. And the prominent activities can be attributed to cycloartane-type triterpene astragalosides largely, which are astragaloside I (AG I), astragaloside II (AG II), astragaloside III (AG III) and astragaloside IV (AG IV) [16]. In particular, AG IV has been used as "marker compound" for quality control because of its various biological activities [17]. And AG III and AG IV are isomeric compounds. Their structures were shown in Fig. 1. Thus, it is important to establish a simple, rapid, and effective method to extract and enrich them.

Secondary metabolites production can be achieved through extraction and enrichment processes typically. The conventional extraction techniques, such as liquid–liquid extraction, solid-phase extraction and supercritical fluid extraction have been used to extract the active ingredients from different plants. However, these methods require large volumes of toxic organic solvents. Besides, extraction and enrichment processes are often separated and operated step by step, the whole operation is cumbersome and time consuming. Therefore, the development of an efficient and target compounds-oriented extraction and enrichment technology with green solvents is in demand.

Although many extract methods have been studied, surfactant extraction is still a novel extraction technique for a wide range of organic and inorganic compounds from the natural plants [18]. Surfactants are amphiphilic molecules with hydrophobic and hydrophilic groups which could modify the interface [18]. Amphiphilic molecules at a lower concentration could make the surface tension lower that results in changing hydrophobic molecules into polar ones [19–21]. However, amphiphilic molecules at or above their critical micellar concentration (CMC) are capable to form micelles which are nanometer-sized "water in oil"

* Corresponding author at: Key Laboratory of Forest Plant Ecology, Ministry of Education, Northeast Forestry University, Harbin 150040, PR China.
E-mail address: yujie_fu@163.com (Y.-J. Fu).
[1] These authors contributed equally to this work and share first authorship.

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