Metabolite Profiles of Red and White Rice Aqueous Extracts Derived at Different Temperatures and Their Relationship with Biological Properties as Determined Using ^{1}H-NMR-Based Metabolomics Analysis

Papichaya Netrprachit[1], Nitra Nuangchamnong[2], Nurul Shazini Ramli[4], Faridah Abas[3, 4], and Sudarat Jiamyangyuen[1*]

[1]Department of Agro-industry, Faculty of Agriculture, Natural Resources, and Environment, Naresuan University, Phitsanulok 65000, Thailand
[2]Science Laboratory Centre, Faculty of Science, Naresuan University, Phitsanulok 65000, Thailand
[3]Laboratory of Natural Products, Institute of Bioscience, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[4]Department of Food Science, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

**Corresponding Author. Email: sudaratj@nu.ac.th*
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ABSTRACT

Consumption of pigmented rice has continued to increase in recent years, due in part to its potential health promoting properties, especially protection against chronic diseases. Chemical extracts of red rice have demonstrated strong ability to scavenge free radicals, however little is yet known about water extracts of red rice. The antioxidant activity, α-glucosidase inhibition, nitric oxide inhibition, and metabolic profiling of this cultivar's water extracts have yet to be investigated. In this study, red rice and white rice were extracted using ultrasound-assisted hydrothermal extraction at three different temperatures. The total phenolic content (TPC) as well as the DPPH radical scavenging, α-glucosidase inhibitory, and nitric oxide (NO) inhibitory activities of each extract were determined. NMR analysis was performed to find out the metabolite profiles of the extracts. Correlations between the metabolites and the biological activities of the rice extracts were then investigated using metabolomics analysis. Results show that the red rice aqueous extracts had a higher TPC than the white rice extracts. The highest extraction temperature led to a decrease in the TPC. However, the extraction temperature did not

affect the radical scavenging, α-glucosidase inhibitory, or NO inhibitory activities of the red rice extracts. The PCA results indicated extract discrimination by extraction temperature. The PLS score plot exhibited the potentials of red rice aqueous extracts on the α-glucosidase and NO inhibitory activities. The ^{1}H-NMR-based metabolomics analysis shows that red rice aqueous extract possesses beneficial properties which can make it useful as an ingredient for functional foods or other products.

Keywords: ^{1}H-NMR-based metabolomics, Biological properties, Red pigmented rice, Hydrothermal extraction, Ultrasonic-assisted extraction

INTRODUCTION

Rice is a staple food eaten daily by much of the world's population, and its consumption shows no sign of declining (Frank et al., 2012). Pigmented rice cultivars such as black, purple, and red rice have gained more and more interest in recent years, due in part to their potential health promoting properties (Min et al., 2012). Those pigmented rice is known to contain phenolic compounds, for example phenolic acids and flavonoids, that have the ability to scavenge free radicals and thereby provide health-promoting benefits (Min et al., 2014). Among those pigmented rice, red rice has been reported to have a stronger antioxidant activity than black rice (Gunaratne et al., 2013). However there have been few studies to investigate the antioxidant properties, biological activities, and metabolite profiling of aqueous red rice extracts, and this is the focus of the current study.

The use of chemical solvents is a common method to obtain extracts from plants. Unfortunately conventional extraction that uses chemical solvents can be time-consuming, require large amounts of the solvent, and pose danger from the chemicals themselves. In contrast, several alternative techniques have been developed which can reduce extraction time and solvent consumption and provide high reproducibility. These alternative techniques include ultrasound-assisted extraction, microwave-assisted extraction, supercritical fluid extraction, high-pressure extraction, and hydrothermal extraction (Tabaraki et al., 2011). That said, some techniques like high-pressure extraction and supercritical fluid extraction have limitations, for example they can be expensive or impractical for large scale manufacturing. One comparatively simple and efficient method is ultrasound-assisted extraction (Pringret et al., 2012). This extraction technique is widely applied in the production of various food ingredients (He et al., 2016).

Hydrothermal extraction is considered a non-toxic and sustainable extraction method providing extracts that are safe and suitable for use as functional food ingredients and supplements. Extraction parameters such as extraction temperature and extraction time can influence the efficiency and yield of the extraction as well as the biological properties of resulting plant extract.