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Instrumental neutron activation analysis of selected elements in Thai jasmine rice

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Abstract

Thai jasmine rice (*Khao Dawk Mali* 105) grown from different cultivation areas within Tung Kula Rong Hai zone in the northeast of Thailand was studied. The essential (Mn and K) and toxic elements (As and Br) in rice samples were determine using instrumental neutron activation analysis under the irradiation and counting facilities available at the Thai Research Reactor with thermal neutron flux of 1.8 x 10^9 cm^{-2} s^{-1} at the Thailand Institute of Nuclear Technology in Bangkok. The Rice Flour (1568a) certified reference material was simultaneously analyzed with the rice samples, the results shown a reliability and reproducibility of this method. Detection limits were obtained in the range of 0.01–1.44 mg kg^{-1}. The results revealed that the rice samples accumulate the elements at different concentrations. The essential elements including Mn and K are present in significant concentrations. Toxic elements (As and Br) are shown at trace levels.

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Keywords: Thai jasmine rice; Neutron activation analysis; Essential element; Toxic element

1. Introduction

Rice is a staple crop for Thai population and is grown mainly in Thailand, especially in northeastern and northern regions. Tung Kula Rong Hai is the most jasmine rice production area in northeastern (Isan) Thailand for

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cultivation of growing of Khao Hom Mali Rice, well-known as Thai Jasmin Rice for consumers around the world [1,2]. However, the Tung Kula Rong Hai area is faced with various problems such as soil deterioration, lessening rice quality and aroma, lack of internationally standardized management and production leading to low product value. Therefore, some cultivators use fertilizers in order to increase crop production and to improve the properties of the nutrient-deficient lands.

Fertilizers, especially, the chemical fertilizers in agriculture used to improve the soil properties, could be a potential source of environmental pollution because some fertilizers contain heavy metals, accumulating in soil and plant system [3]. The elements composition of plant can reflect the soil properties. Some metals are not essential nutrients for plants. However, so much high contaminations of metals may become detrimental to human health because they can transfer into the human food chain. Therefore, it is necessary to monitor the levels of essential, non-essential and toxic elements in rice in order to increase our information of the distribution of trace elements both geographically and the food chain.

Several methods such as inductively coupled plasma mass spectrometry (ICP-MS), atomic absorption spectrometry (AAS) and graphite furnace atomic absorption spectrometry (GF-AAS) have been used for the analysis of multi-element in foods which are of interest because of their effect on human health [4-6]. It is known that instrument neutron activation analysis (INAA) is a powerful technique for the determination of various elements which play an important role in human health [7]. It is also a non-destructive, versatile, sensitive, multi- element analytical technique with a very low detection limits that can be used for the investigation of rice samples.

The objective of this work is to determine the elemental concentrations in Thai jasmine rice using INAA. Data from this study would provide an invaluable source of both essential and toxic elements in the information database of Thai jasmine rice and an attempt for explain variation in elemental contents from different geographical zones.

2. Materials and methods

2.1. Sample collection

Fifty paddy jasmine rice samples collected from 10 districts in the Tung Kula Rong Hai area are represented as M1-M10. This area is located in the provinces of Surin, Mahasarakham, Sisaket, Roi Et and Yasothon. In each district, the samples were obtained from 5 different sampling areas.

2.2. Sample preparation

The rice samples were air-dried at room temperature, crushed to a homogeneous fine powder by blender. The dried samples were grinded using mortar until homogenized powder and then oven-dried at 60 °C. Samples (approximately 100 mg) were sealed in polyethylene bags prior to neutron irradiation. These containers were packed into rabbit for medium irradiation. The properties of used radionuclides, γ-energies, and other details of the analysis are presented in Table 1.

Table 1. Nuclear parameters of all elements interested.

Element	Radionuclide	Half-life	γ-ray (keV)	Irradiation time (h)
As	^{76}As	26.3 h	559.1	7
Br	^{82}Br	1.47 days	776.5	7
Mn	^{56}Mn	2.58 h	846.8	7
K	^{42}K	12.36 h	1524.6	7

2.3. Gamma-ray spectrometry

After the appropriate decay times, all elements were analyzed by γ-spectrometry (EG&ORTEC, USA) using a high purity germanium (HPGe) detector with relative efficiency of 60% and resolution of 1.95 keV for 1332.5 keV peak of ^{60}Co. The γ-ray spectra were processed using the Gamma Vision-32 computer program. For the energy