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Sodium selenite regulates phenolics accumulation and tuber development of purple potatoes

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ABSTRACT

It has been reported that selenium could increase nutritional components as carbohydrates, organic selenium, proteins and total amino acids of potatoes. However, there have been few reports on selenium-enriched purple potatoes as yet. In this study, the effects of selenium on phenolics and tuber development of purple potatoes were investigated. The main phenolic components in purple potatoes were separated and identified as chlorogenic acid, caffeic acid, malvidin-5-glu-3-dirhamnose-glucose, caffeic acid-acetylrhamnose ester and caffeic acid-prenylrhamnose ester. The total phenolics including malvidin-5-glu-3-dirhamnose-glucose could be directly quantified at 325 nm, with chlorogenic acid as a standard. The main phenolic components were significantly increased by selenium. Total tuber weight was significantly increased by selenium ($R^2 = 0.964$, $P = 0.002$). In conclusion, selenium significantly increased phenolic components and promoted tuber formation of purple potatoes; in this sense, selenium-enriched purple potato should be a better functional food.

1. Introduction

Phenolics are the main nutritional components in potatoes. Purple potatoes are the main sources for phenolics and anthocyanins (Jansen and Flamme, 2006). Anthocyanins contained in purple potatoes were found to show functions in antioxidation (Steed and Truong, 2008; Han et al., 2006a,b, 2007; Reyes et al., 2005; Brown et al., 2003; Lachman and Hamouz, 2005; Brown et al., 2007), antitumor (Yoshimoto and Okuno, 2001; Kazuya and Hiroshige, 2006) and liver protection (Han et al., 2006a). Anthocyanins could be easily absorbed by human body (*Harada* et al., 2004). So, compared to "white potatoes", purple potatoes were more valuable in health protection. Nowadays, purple potatoes were widely used as functional food in Europe, North America and Southeast Asia.

Selenium, a trace element, as a constituent of selenoproteins and some important enzymes as GSH-Px and some dehydrogenases, were reported to have physiological functions as antioxidation (Wong et al., 2010), anticancer (Tara et al., 2010), immunity stimulation (Ramoutar and Brumaghim, 2010) and inhibiting HIV (Silva et al., 2010). The bio-activity of selenium depends on its chemical form. Organic selenium-containing compounds such as selenomethionine and methylselenocysteine were better tolerated and exhibit anticarcinogenic activity (Yu et al., 2007). Many plants showed abilities in absorbing and transforming inorganic selenium into organic selenium (Sors et al., 2005). So selenium tolerant plants were widely used for selenium supplementation. In fact, selenium-enriched food was used as either selenium supplementation or functional food, since selenium could enhance accumulation of some active compounds (Dong et al., 2012, 2013). There have been some reports on selenium increasing carbohydrates, organic selenium, total amino acids, antioxidation activity and photosynthesis of potatoes (Turakainen et al., 2004; Cyrus et al., 1991; Seppänen et al., 2003; Cuderman et al., 2008; Germ et al., 2007). However, no reports about selenium-enriched purple potato have been seen as yet. In this study, cultivation of selenium-enriched purple potatoes

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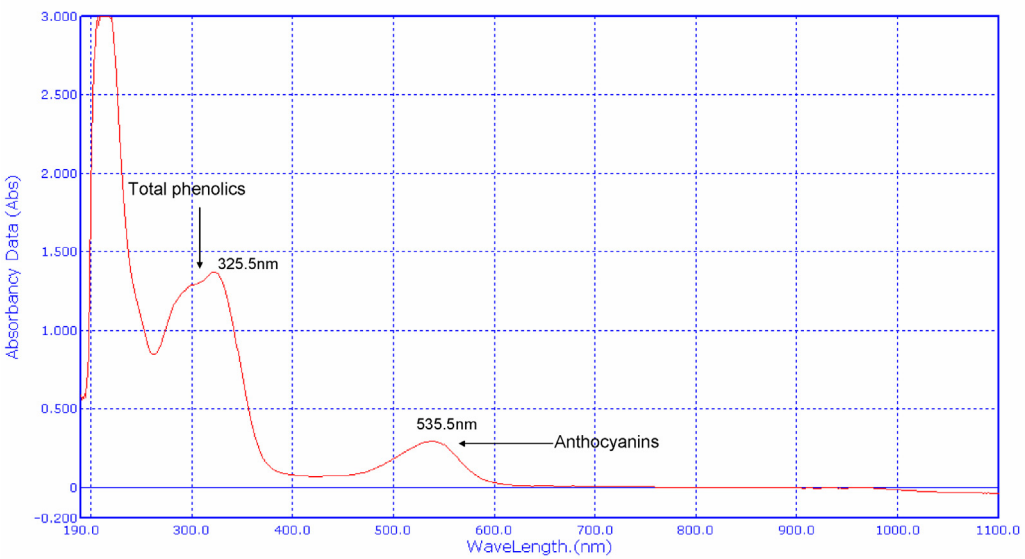

Fig. 1. UV–vis spectrum of purple potato extract.

was conducted, and effects of selenium on tuber growth, phenolics and anthocyanins were investigated.

2. Materials and methods

2.1. Chemicals and apparatus

Ultrasonic cleaning bath (Shenzhen Jietai Ultrasonic cleaning apparatus Co. Ltd., Shenzhan, China, PS-40, 40 kHz, 240 W) were employed for extraction of total phenolics and anthocyanins. An UV–vis spectrophotometer (Shanghai Youke Instrument and Meter Co., Ltd., Shanghai, China) was used for analysis of the extracts and separated components. Standards of chorogenic acid and caffeic acid were from the Sangon Biotech (Shanghai, China). HPLC system (Hangzhou Saizhi Sci. & Tech Co., Ltd., Hangzhou, China) used for phenolics separation and quantification consists of N2000 ChemStation, STI501 pump, STI 501 UV detector and Lichrospher C18 column (4.6 mm × 250 mm, Jiangsu Hanbon Sci. & Tech Co., Ltd., Jiangsu, China). LC–MS analysis was performed on an Agilent1100 series with an LC–MSD trap SL (Agilent Technologies, Berlin, Germany). Preparative chromatography (Hangzhou Saizhi Sci. & Tech Co., Ltd., Hangzhou, China) with a C18 column (50 mm × 250 mm, Agilent Technologies, Kansas, USA) was used for preparation of the three components (malvidin-5-glucose,3-dirhamnose-glucose; caffeic acid-acetylrahmnose ester; caffeic acid-prenylrahmnose ester).

2.2. Cultivation and sampling

Sodium selenite was reported to be good form of selenium fertilizer for plants (Dong et al., 2013) and used as selenium source in this study. Sodium selenite was added into the MS solution ($KNO_3/NH_4NO_3/KH_2PO_4/MgSO_4{\cdot}7H_2O/CaCl_2{\cdot}2H_2O/KI/H_3BO_3/MnSO_4{\cdot}4H_2O/ZnSO_4{\cdot}7H_2O/Na_2MoO_4{\cdot}2H_2O/CuSO_4{\cdot}5H_2O/CoCl_2{\cdot}6H_2O/Na_2EDTA/FeSO_4{\cdot}7H_2O$ = 1900/1650/170/370/440/0.83/6.2/22.3/8.6/0.25/0.025/0.025/37.25/27.85, mg/L) to final Se-concentrations of 0, 10, 20, 30, 40, 50 mg/kg dried quartzsands (called Se-MS solution). Quartz sands were collected by 30 mesh screen and cleaned with pure water. The dried cleaned sands were well mixed with the prepared Se-MS solution in the ratio of 0.25 kg Se-MS solution/1.0 kg dried sands (called selenium-soils). Seedlings of purple potatoes were planted in the prepared selenium-soils. The cultivation was conducted outdoors under glass canopy and irrigated with distilled water to maintain the stable water contents (60%) of the selenium-soil. The water contents of the selenium-soils were analyzed once every week, and the amount of distilled water irrigated were counted according to the water contents of the selenium-soils. The cultivation was from March to July, in Enshi, China, with the average temperature of 23.5 °C and altitude of 531.8 m. Tubers were harvested after 151 days growth, then washed, weighed and stored at 4 °C for analysis of phenolics and anthocyanins.

2.3. Separation, identification and quantification of phenolics

Separation and identification of the main phenolic components: based on extraction optimization (data not shown), tubers were weighed, sliced and ground with 70% ethanol. The mixture was ultrasonicated for 0.5 h and centrifuged at 3250 × *g*; then the supernatants were used as total extract. The total extracts were scanned within 190–1100 nm to primarily detect possible phenolic components (Fig. 1). The main absorbance peak was at 325.5 nm (Fig. 1), which indicated the possible presence of caffeic acid derivatives. Based on the UV–vis scanning analysis, separation of the extract was conducted according to our published methods (Dong et al., 2013). Namely, acetonitrile as solvent A (1.0% acetic acid as solvent B) 0–18 min, 15–60%, 18–20 min, 60–100%. Column temperature 25 °C, sample volume injected 20.0 μl, flow rate 1.0 ml/min. The detector was set at 325 nm. Then the separated components were identified by LC–MSD-TRAP-XCT (Agilent 1100) which was conducted by Analytical and Testing Center of Huazhong University of Science and Technology. Molecular weight and structure were obtained by MS data and UV spectra.

Preparation and calibration of the standards: Fresh purple potatoes were cut into pieces and vacuum dried at 60 °C, then the dried purple potatoes were ground into powders through 40 mesh screen. 200 g dried powders were extracted with 70% ethanol. Based on the above HPLC separation method, the main components of the extract were separated using preparative HPLC. And then the separated components were dissolved with 70% ethanol to different concentrations to make calibration curves which were used for quantification of the main phenolic components of the purple potatoes.