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Influence of different cultivation systems on bioactivity of asparagus

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A R T I C L E I N F O

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A B S T R A C T

Evaluation of functional and bioactive compounds of *Asparagus officinalis* L. growing in conventional and organic greenhouse and conventional open – field farming was the aim of this research. Polyphenols in cladodes grown conventionally were higher than organic. Flavonoids and carotenoids were the highest in cladodes in open field. Organic spears were richer in total phenolics (+6.9% and +19.1%) and flavonoids (+4.7% and 16.8%) and showed higher *in vitro* averages of antioxidant activities by three radical scavenging assays (+12.5% and + 22.2%) than conventional. Partial differentiation of organically and conventionally grown samples was proved by multivariate statistics. The binding properties of polyphenols to HSA were relatively high in comparison with other plants. A strong positive correlation of binding properties and bioactivity of asparagus was estimated. All new found aspects for the first time lead to recommendation of inclusion of all investigated asparagus plants into the human diet in a wider scale.

1. Introduction

Human diet has an important role in the protection against oxidative stress. This health-protecting factor has been partly attributed to the compounds with proven antioxidant capacity, preferably to fruits and vegetables being major sources of dietary antioxidants, possessing prevention of different diseases (Morales-Soto et al., 2014). Asparagus (*Asparagus officinalis* L.), as a healthy and perishable vegetable, is processed after harvest to minimize the deterioration of its physical and chemical quality (Sun, Powers, & Tang, 2007; Sun, Tang, & Powers, 2007). Extracts of *Asparagus officinalis* L. exert antidiabetic effects by improving insulin secretion and (sup)-cell function, as well as the antioxidant status (Hafizur, Kabir, & Chishti, 2012). The hypolipidaemic and hepatoprotective effects of ethanolic (EEA), aqueous (AEA) and *n*-butanol (BEA) extracts from *Asparagus officinalis* L. by-products were evaluated in mice fed a high-fat diet, and AEA in streptozotocin-induced diabetic rats. EEA, AEA and BEA extracts have strong hypolipidaemic, hepatoprotective, hypoglycaemic and hypotriglyceridaemic functions and could be used as supplements in healthcare foods and drugs in preventing of diabetic complications associated with hyperglycaemia and hyperlipidaemia (Zhao et al., 2011; Zhu et al., 2011). Consumption of asparagus in South Korea increased as it is known to contain a high amount of components with functional and pharmacological benefits for human health including polyphenols and flavonoids (Lee, Heo, Bae, & Ku, 2015). Throughout the world, *Asparagus officialis* L. is cultivated in an open field conventional system but used to show significantly lower yield compared to greenhouse production with organic and chemical fertilizers. It should be noted here, that in South Korea, most of asparagus cultivation is growing in the greenhouse, because of heavy summer rain and high incidence of plant diseases. This matter requires high expenses for the construction of greenhouse system (Lee et al., 2015). Asparagus consumers are interested in organic production, but it is very difficult to manage organic growing farming without fertilizers. There have been some studies showing a higher level of bioactive compounds in organic bell pepper fruits (Hallmann & Rembialkowska, 2012; López, Fenoll, Hellín, & Flores, 2014), two tomato types (Hallmann, 2012; Vallverdú-Queralt, Medina-Remón, Casals-Ribes, & Lamuela-Raventos, 2012; Vinha, Barreira, Costa, Alves, & Oliveira, 2014), *Brassica rapa* L. (Conversa, Bonasia, Lazzizera, & Elia, 2016) and pomegranate (Marathe, Sharma, Murkute, & Babu, 2017). The results were compared with conventional fruits and variety of other plants, but not all above mentioned studies have been consistent in this respect. Organically and conventionally grown Italian

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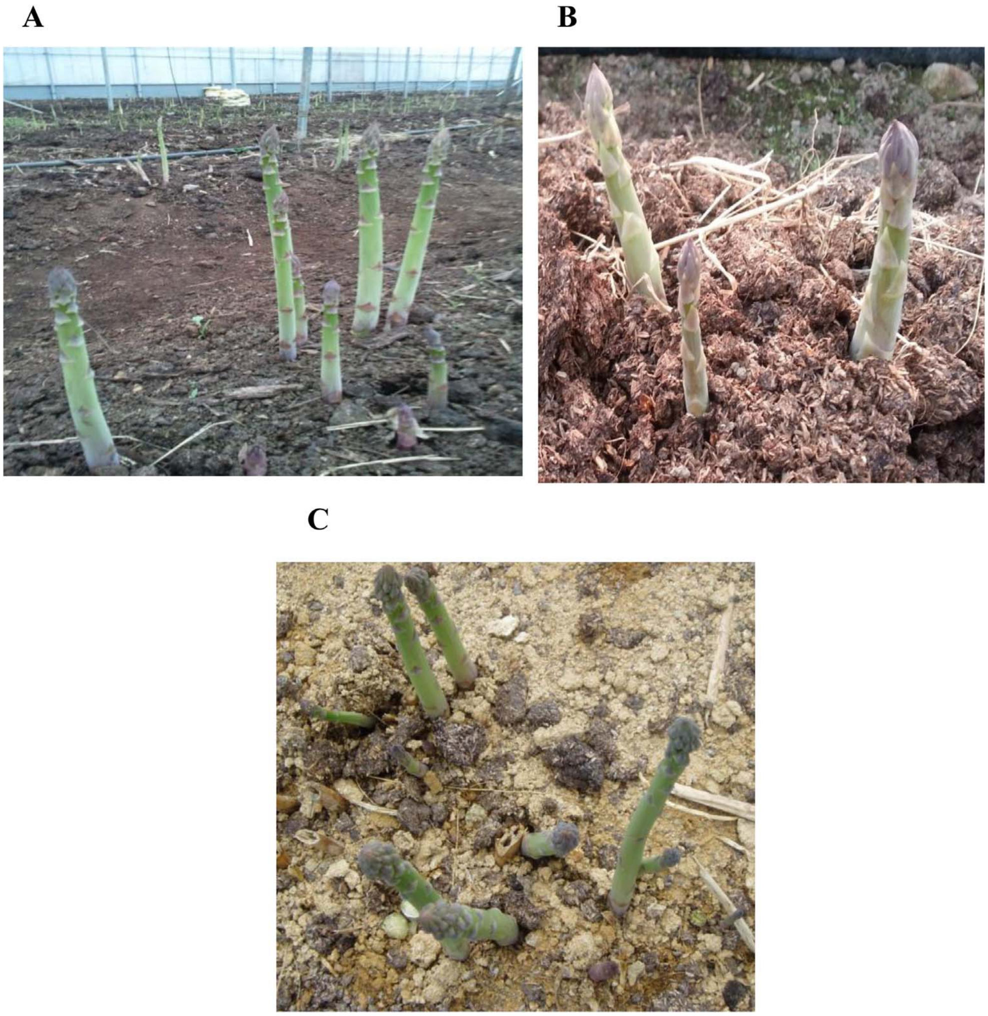

Fig. 1. A, Organic asparagus cultivation in the greenhouse; B, Conventional asparagus cultivation in the greenhouse; C, Conventional asparagus cultivation in the open field.

cauliflower (*Brassica oleracea* L. subsp. botrytis) was characterized by Lo Scalzo et al. (2013). The effects of organic and conventional cultivation methods on composition of eggplant fruits were evaluated by Raigón, Rodríguez-Burruezo, and Prohens (2010). Oppositely the information on the properties of conventionally and organically grown *Asparagus officinalis* L. is lacking.

Only in a few reports the differences in asparagus cultivations were discussed. So, Monokrousos, Papatheodorou, and Stamou (2008) investigated soil biochemical variables among fields with different durations of organic and conventional cultivations for *Asparagus officinalis* L. All fields were planted with a common perennial plant and were subject to the same seasonal management cycle as fertilizing and crop harvest. It is well established that in response to biotic and abiotic stresses, that occur frequently in organic farming, plants activate a series of counteracting measures, including molecular and physiological mechanisms that consent short- and long-term adaptation to a sub-optimal environment (Conversa et al., 2016; López et al., 2014; Monokrousos et al., 2008). Among these stress-induced factors, one of the dominant is the accumulation of antioxidant molecules with multiple functions in ensuring plant growth and development under stress conditions (Akula & Ravishankar, 2011). The same molecules are also important for human health. Therefore a subject of this study was to compare the antioxidant and quenching properties of three cultivation systems (organic and conventional in greenhouse, and conventional in open field) of *Asparagus officinalis* L. The compositional profiles of cladodes and fresh spears were evaluated in three cultivation systems using antioxidant scavenging assays and fluorescence spectroscopy. The quenching properties of polyphenols were determined by the interaction of the main drug career in blood human serum albumin (HSA).

2. Materials and methods

2.1. Chemicals

Trolox (6-hydroxy-2,5,7,8,-tetramethyl-chroman-2-carboxylic acid); 2,2′-azobis-2-methyl-propanimidamide; $FeCl_3$ x6H_2O; Folin–Ciocalteu reagent (FCR); Tris, tris (hydroxymethy1)aminomethane; lanthanum (III) chloride heptahydrate; $CuCl_2$ x2H_2O; and 2,9-dimethyl-1,10-phenanthroline (neocuproine), potassium persulfate, rutin, sinapic acid and human serum albumin were obtained from Sigma Chemical Co., St. Louis, MO, USA. 2,4,6-tripyridyl-s-triazine (TPTZ) was purchased from Fluka Chemie, Buchs, Switzerland. All reagents were of analytical grade. Deionised and distilled water were used throughout.

2.2. Characterization of investigated samples

The experiment was undertaken at commercial planting of asparagus at Jeju island (Latitude 33°49′, Longitude 126°53′), South Korea. Asparagus (*Asparagus officialis* L. cv. ‘UC157’) seeds were germinated and were grown in plastic cell trays containing commercial media. In both greenhouse and open – field cultivation systems, asparagus seedlings were transplanted to the bottom of 30 cm deep furrow. Before transplanting, beef manure was applied (6 ton per ha) to organic cultivation system. Single row spaced 1.5 m and spacing among plants was 40 cm (16,500 plants per ha). Asparagus cultivation systems in South