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Short Communication

Variations in the carotenoid and anthocyanin contents of Korean cultural varieties and home-processed sweet potatoes

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ABSTRACT

The sweet potato is an important industrial crop and a source of food that contains useful dietary fiber and vitamins. Recently, orange- and purple-fleshed varieties have come under the spotlight due to their healthful components, carotenoids and anthocyanins, respectively. In this study, an HPLC-DAD method was applied to determine the carotenoid composition and content in nine Korean cultural varieties of sweet potato. Changes in carotenoid contents and composition were also observed during home-processing of an orange-fleshed cultivar with high carotenoid content (530 ± 60 μg/g of dry weight, DW as all-*trans*-β-carotene). A loss of the carotenoids was observed for all of the home-processing methods examined; the baked or boiled or steamed sweet potatoes had higher amounts of all-*trans*-β-carotene (246 ± 34, 253 ± 29 and 240 ± 21 μg/g DW, respectively) than pressure-cooked, sautéed and fried ones (194 ± 21, 201 ± 28 and 111 ± 19 μg/g DW, respectively). Interestingly, *cis*-isomer of the all-*trans*-β-carotene, 13Z-β-carotene was found in elevated amounts in all of the processed samples, particularly in baked, pressure-cooked and steamed sweet potatoes compared to control. Variations in anthocyanin content in the nine cultural varieties and home-processed sweet potatoes were also determined by an HPLC-DAD method.

1. Introduction

Carotenoids are synthesized by plants and some microorganisms, and most of them are liposoluble. They are responsible for the red, yellow, and orange colors, and act as photosynthesis aids and for the photoprotection of their hosts (Pfander, 1992; Demmig-Adams et al., 1996). Humans and animals are not able to synthesize carotenoids and need to acquire them by alimentation. Carotenoids are used in food and feed as colorants, flavorings, and nutritional supplements, being a source of provitamin A. The health benefits of carotenoids to humans and animals are becoming increasingly apparent. For example, there is evidence that these pigments may act as antioxidants and protect humans from serious disorders such as skin degeneration and aging, cardiovascular disease, certain types of cancer, and age-related diseases of the eye, such as macular degeneration or cataracts (Tapiero et al., 2004; Stahl and Sies, 2005; Rao and Rao, 2007).

Anthocyanins are polyphenolic water-soluble pigments and glycosides of polyhydroxy and polymethoxy derivatives of 2-phenylbenzopyrylium or flavylium salts. These compounds play a role in attracting animals in pollination and seed dispersal; they may also enhance plant resistance to insect attack, act as endogenous plant antioxidants and photoprotectors (Strack and

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Wray, 1993; Delgado-Vargas et al., 2000). Evidence also suggests that this group of phytochemicals, besides being nontoxic and non-mutagenic, could exhibit multiple biological effects, such as antioxidant activity, anti-inflammatory action, inhibition of blood platelet aggregation, and antimicrobial activity, and could be used in the treatment of diabetic retinopathy and prevention of cholesterol-induced atherosclerosis (Luo et al., 2014; Pascual-Teresa et al., 2013; Zheng and Wang, 2003).

Sweet potato is the root of *Ipomoea batatas* (L.) Lam. (Convolvulaceae) and an important industrial crop and source of food that contains useful dietary fiber and vitamins (Kim et al., 2013). It has been widely consumed in Asia including China, Japan and Korea (Yamakawa and Yoshimoto, 2002). Recently, orange- and purple-fleshed varieties have come under attention owing to their healthful components, carotenoids and anthocyanins, respectively. As a food material, sweet potato is usually served after processing. Steaming and baking are the most popular and traditional home processing methods in Korea.

In this study, the major carotenoid and anthocyanin contents in sweet potato were determined for nine Korean cultural varieties including orange-fleshed sweet potato varieties (Juhwangmi and Sinhwangmi) and purple-fleshed varieties (Sinjami and Yeonjami). The stability of these natural pigments was also evaluated during several cooking process.

2. Materials and methods

2.1. Plant materials

Nine freshly harvested sweet potato cultural varieties were gifted from Bioenergy Crop Research Center, National Institute of Crop Science. The roots were from the same harvest batch, and harvested at 120 days after planting in Mooan, Jeonnam Province, June, 2013. The triplicate roots were washed and freeze-dried for carotenoid and anthocyanin analysis. All of the lyophilized samples were stored at −80 °C until the analysis was done, and outer layer was peeled before the analysis.

2.2. Home-processing methods

An orange-fleshed cultural variety, Sinhwangmi, and a purple-fleshed cultural variety, Sinjami, (average weight approximately 230 g) were used in this experiment. The root of the sweet potato was washed with tap water and dried at room temperature. Each triplicate root was peeled for frying and sautéing, and cooked by each home-processing method. All of the cooked samples were kept for 30 min at room temperature and then freeze-dried.

Baking. Samples (one root into three pieces) were baked for 20 min in an aluminum fan with a lid on a portable gas stove.

Boiling. Three chopped fresh roots (one root into six pieces) were boiled in a stainless steel pot with a lid for 15 min in 100 mL of natural mineral water.

Frying. Fresh sweet potato was chopped into 0.3 cm × 0.5 cm × 5 cm pieces and fried at 170 °C for 1 min in 300 mL of rice-bran oil.

Pressure-cooking. Sweet potato (one root into six pieces) was cooked at a medium heat for 10 min in a pressure cooker (Kitchen Sense) containing 100 mL of natural mineral water.

Sautéing. Sweet potato was chopped into 0.3 cm × 0.5 cm × 5 cm pieces and sautéed in a fry fan for 3 min with 5 mL of rice-bran oil with 1 g of salt.

Steaming. Three chopped fresh roots (one root into six pieces) were steamed on a perforated stainless steel insert with a tripod base in a stainless steel pot for 10 min with 50 mL of natural mineral water.

2.3. Carotenoid analysis

All extraction procedures were performed under subdued light to avoid degradation loss of the pigments. Two hundred and fifty milligram of the lyophilized samples were homogenized in a pre-chilled mortar and a pestle with 15 mL of acetone (0.01% butylated hydroxytoluene, BHT), sea sand, Na_2SO_4 and $NaHCO_3$. The solution was transferred to 15-mL conical tube and sonicated three times for 10 min. The extract was centrifuged at 5700 × *g*, 4 °C for 10 min (Eppendorf 5430R, Germany), and 5 mL of the supernatant was dried under a flow of N_2 gas and dissolved in 500 μL of a CH_2Cl_2 and acetone mixture (1:1, v/v). This sample solution was filtered through a 0.45 μm membrane filter (Whatman, PTFE, 13 mm) prior to HPLC analysis. For fried or sautéed materials, CH_2Cl_2 and acetone were used to extract the carotenoids.

Carotenoids were quantified using an external calibration method by the HPLC-DAD method described in our previous report (Kim et al., 2013). At this chromatographic condition, standard carotenoids gave peaks at the following t_R (min): 32.3 for β-cryptoxanthin, 35.8 for 13*Z*-β-carotene, 38.4 for all-*trans*-β-carotene and 39.6 for 9*Z*-β-carotene. Methanol, water and methyl *tert*-butyl ether used in the HPLC system were all of HPLC grade and the other chemicals were extra grade.

2.4. Anthocyanin analysis

Two hundred and fifty milligrams of the lyophilized samples were ground with sea sand and extracted three times by sonication for 10 each min with 15 mL of 1% HCl solution in methanol. The extract was centrifuged at 5700 × *g*, 4 °C for 10 min and the supernatant was filtered through a 0.45 μm membrane filter (Whatman, PTFE, 13 mm). For fried or sautéed materials, CH_2Cl_2 was used prior to the extraction procedure to remove the oily substance. The anthocyanins in samples were identified and quantified according to the previously reported method (Kim et al., 2012). The Agilent 1260 HPLC system (Agilent, Waldbronn, Germany) consisted of a temperature controlled autosampler, column oven, diode-array detector, and binary pump. The Chemstation software (Agilent, Avondale, CA, USA) was used to operate the HPLC-DAD system.

2.5. Colorimetric evaluation

The color attributes of transverse root sections were measured with a colorimeter (Konica Minolta CR-400, Osaka, Japan). Before testing, the colorimeter was calibrated using a Minolta standard white reflector plate. The color was measured at least three times, with a maximum of five, depending on the size of each root. The data were presented as L^* (lightness), a^* (redness), and b^* (yellowness) values from the Hunter color system. The obtained color attributes before and after baking were used to calculate ΔE, representing the total color differences between samples before and after baking as follows: $\Delta E = ((\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2)^{1/2}$ (Jing et al., 2012).

2.6. Antioxidant activity test with ABTS radical

ABTS radical was generated by the previously reported method (Re et al., 1999). The antioxidant activity of each anthocyanin extract was expressed as Trolox (Sigma, USA) equivalent antioxidant capacity (TEAC, μM).

2.7. Statistical analysis

All of the contents are expressed as the means ± standard deviations (SD) of triplicate determinations. The differences among