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Profiles of phenolics, carotenoids and antioxidative capacities of thermal processed white, yellow, orange and purple sweet potatoes grown in Guilin, China

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Abstract

The objectives of this study were to systematically compare phenolic profiles, carotenoids profiles and antioxidant activities of raw and cooked sweet potatoes of five varieties (white, yellow, orange, light purple and deep purple). Total phenolic content (TPC), monomeric anthocyanin content (MAC), total carotenoid content (TCC), 2-diohenyl-1-picryhydrazyl (DPPH) free radical scavenging capacities and ferric reducing antioxidant powder (FRAP) were determined by colorimetric methods. Higher anthocyanin contents and antioxidant capacities were detected in purple sweet potato species, while higher carotenoid contents were detected in yellow and orange sweet potato. All cooked sweet potato exhibited significantly ($p < 0.05$) lower TPC, MAC, TCC, DPPH and FRAP values as compared to the respective raw samples. Under the same cooking time, steaming was good for the retention of TPC, roasting was good for keeping anthocyanins, and boiling was beneficial to preserve carotenoids.

Keywords: Sweet potato; Processing; Phenolics; Carotenoids; Antioxidant capacities

1. Introduction

Sweet potato is a crop with rich nutritional values including carbohydrates, dietary fibers, vitamins, and minerals [1]. Currently, it is the sixth most popular and abundant staple food worldwide. It plays an important role in solving the issues of food, energy, natural resources and environment. Four commonly available colored sweet potato species in China are white, yellow, orange, and purple, which have completely different chemical compositions.

The major bioactive substances in purple sweet potato are phenolics and anthocyanins. Phenolics are the antioxidant molecules with at least one aromatic ring and one or more hydroxyl groups [2]. Anthocyanins, are a group of water-soluble flavonoids. As the predominant pigments and functional phenolics in purple sweet potato, anthocyanins are the naturally strong free-radical scavengers, which provide many pharmaceutical values including anti-oxidation, anti-tumor capacities, and prevention and treatment of cardiovascular diseases. In yellow or orange sweet potato species, carotenoids (such as β-carotene) act as the primary pigment molecule [3] as well as the source of provitamin A, which shows vitamin A activity [4]. Carotenoids have strong antioxidant capacity to scavenge free radicals because of their conjugated double bonds [5].

Generally, sweet potato is cooked, either by boiling, steaming or roasting, before consumption. Such thermal processing can cause impairment of the functional compounds of sweet potato. There have been reports of negative correlation between heat treatments (steaming and baking) and some bioactive substances, such as anthocyanins. Carvalho et al. [6] reported a dramatic decrease in both total carotenoid and β-carotene contents of sweet cassava after cooking.

Although the benefits of sweet potato are widely established through numerous studies, there is limited information about

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how their functional components (e.g., phenolic substances, carotenoids), and antioxidant capacities are affected by different home-cooking ways. In the present study, we investigated the changes in total phenolic content (TPC), monomeric anthocyanin content (MAC) and total carotenoid content (TCC), as well as antioxidant capacities (DPPH and FRAP) of five species of sweet potato after three types of ordinary thermal processing, such as boiling, steaming and roasting with a view to understand detail changes in the functional compositions of different chemical constituents.

2. Materials and methods

2.1. Chemicals and reagents

Folin–Ciocalteu reagent, 2-diohenyl-1-picryhydrazyl (DPPH), and 2,4,6-tri(2-pyridyl)-s-triazine (TPTZ) were purchased from Shanghai Yuanye Biological Technology Co., Ltd (Shanghai, China). The 6-hydroxy-2,5,7,8-tetramethlchroman-2-carboxylic acid (Trolox) was obtained from Sigma–Aldrich Co. (Shanghai, China). Absolute ethanol was obtained from Tianjin Fuyu Fine Chemical Co., Ltd. Other chemical reagents were supplied by Tianjin Damao Chemical Reagent Co., Ltd. (Tianjin, China). All chemicals were analytical grade unless specially mentioned.

2.2. Sweet potato samples

Five species of sweet potatoes were sampled, including light purple, yellow, white, orange, and deep purple (shown in Fig. 1 and Table 1). All of them were cultivated in Guilin Agricultural Research Institute in Guilin of Guangxi Province (China) in 2013.

2.3. Cooking approaches and cooking time

Three thermal processes were performed for sweet potatoes with five species (light purple, yellow, white, orange and deep purple). All sweet potato samples were not peeled before and during heat treatment. After cooking, they were peeled. Boiling, steaming and roasting processes imitated cooking methods at home as far as possible.

For the boiling treatment, about 130 g of sweet potato was added to 650 mL tap water (sample/water – 1:5, w/v). The water was heated to its boiling point before being added to the different kinds of sweet potatoes, and then cooked in the electric hot plate cooker for about 30 min. For the steaming process, approximately 130 g sweet potato was placed in a steam cooker, in which 1 L tap water was filled. Steaming was conducted for about 30 min after the water generated steam. For the roasting process, an electric oven (Galanz, China) was applied to preheat to 230 °C. After that, about 130 g of sweet potato was placed in the oven and roasted for 30 min at 230 °C.

All samples (including non-cooked and cooked) were lyophilized by freeze-dryer (Labconco Corporation, Kansas City, MO, U.S.A.), and then sweet potato samples were ground by a grinder (Beijing Zhongxing Weiye Instrument Co., LTD). Ultimately, sweet potato powder were passed through 80 # mesh and stored at 4 °C in a refrigerator (Dukers) for further studies.

2.4. Color measurement

The color attributes of sweet potato were measured by Khroma Meter Difference with Colorimeter CR-410 (Konica Minolta, Japan) according to the method of Wang et al. [7] with slight modifications. The color was expressed in $L^*a^*b^*$, where the L^* represents lightness ($L^*=0$ yields black and $L^*=100$ denotes white), the a^* expresses red (+) or green (−), and the b^* indicates yellow (+) or blue (−). L^*, a^* and b^* parameters were measured against a white calibration plate and were directly obtained from the apparatus. ΔE is directly displayed and calculated in this colorimeter by the following formula:

$$\Delta E^*_{ab} = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

2.5. Extraction of samples

Accurately, 0.5 g of each ground dry sample was weighed, and extracted with 5 mL of acidic 70% acetone (acetone/water/acetic acid – 70:29.5:0.5, v/v/v) in a set of capped centrifuge tubes by shaking on an orbital shaker at ambient temperature for 3 h and setting in the dark for 12 h. Then, the extracts were centrifuged at 5000 r per minute for 10 min, and the supernatants were collected. Residues were extracted with 5 mL of extraction solvent for two more times. Three extracts were combined and stored at 4 °C in the dark. The extraction of every sample was conducted in triplicate. The final volume of each extract was recorded.

2.6. Determination of total phenolic content (TPC)

The total phenolic content was evaluated according to the method of Xu and Chang [8] with no modifications. Briefly, the absorbance was measured by UV-Visible spectrophotometer (TI-1901, Beijing Purkinje General Instrument Co., Ltd, China) at 765 nm against blank-distilled water. The total phenolic content (TPC) was expressed as milligrams of gallic acid equivalents (mg of GAE/g sweet potato).

2.7. Determination of monomeric anthocyanin content (MAC)

Monomeric anthocyanin content (MAC) was based on a pH differential method described previously by Lee et al. [9] with no modifications. The MAC was calculated in the form of w/w% of total anthocyanin in the samples using the molecular weight for cyanidin-3-glucoside (449.2 g/mol) and its extinction coefficient (26 900 L cm^{-1} mol^{-1}). MAC was expressed as cyanidin-3-glucoside equivalents because of its historical usage for similar assays and its wide commercial availability [9].