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EFFECTS OF COOKING METHODS ON THE ANTHOCYANIN LEVELS AND ANTIOXIDANT ACTIVITY OF A LOCAL TURKISH SWEETPOTATO [*Ipomoea batatas* (L.) LAM] CULTIVAR HATAY KIRMIZI: BOILING, STEAMING AND FRYING EFFECTS

Ozlem TOKUSOGLU[1] , *Zihin YILDIRIM*[2]

[1]*Celal Bayar University Faculty of Engineering, Department of. Food Engineering, Manisa,TURKEY*
[2]*Ege University, Faculty of Agriculture Department of Field Crops, Izmir, TURKEY*
[1]*Corresponding author: ozlem.tokusoglu@bayar.edu.tr*

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ABSTRACT

The study was conducted on the anthocyanin (TA) level and antioxidant activity (AA) of a local genotype of sweetpotato (Hatay Kirmizi) and heating process effects including boiling, steaming, frying on TA and AA levels. The anthocyanin calibration graph of standard cyanidin-3-glucoside gave linear equation (y= 0.0113x+ 0.0045 ; R^2 = 0.9986). Anthocyanin level of sweetpotato Hatay Kirmizi (as cyanidin-3-glucoside (C3G) equivalent) was determined as 11992 ± 15.86 mg/100g) (n=8) (p≤0.05). Anthocyanins were detected as 13767 ± 8.94 mg/100g; 24756 ± 6.70 mg/100g; 6755 ± 10.22 mg/100g in boiled, steamed and fried sweetpotatoes, respectively (n=2) (p≤0.05). The total anthocyanins increased as 1.14 fold after boiling process and increased 3.22 fold after steaming process and decreased 1.78 fold after frying process (p≤0.05). It was determined that steaming process, was the most effective among the heat-treated sweetpotatoes (HTSPs). Antioxidant activities of the HTSPs was 78.76%, 89.67%, 97.92% and 57.89% (as radical inhibition percent), respectively. With using steaming process, radical inhibition percent increased 1.24 fold. Tubers of sweetpotato Hatay Kirmizi can be consumed not only steamed > boiled > fried forms but also can be processed into food products, such as muffins, cookies, biscuits, breakfast foods with longer shelf-life, and improved characteristics. It was proposed that sweetpotato Hatay Kirmizi can be processed into flour and used as a thickener, antioxidant enhancer and color source in industrial powder soups, gravy, extruder snacks, and some bakery products.

Keywords: Sweet potato, anthocyanin, antioxidant activitiy, Hatay Kirmizi

INTRODUCTION

Sweetpotato [*Ipomoea batatas* (L.) LAM] is among the most important food crops feedings millions of people in the developing world according to data from the Food and Agriculture Organization (FAO). It is grown in many tropical, subtropical and temperate regions (Bouwkamp, 1985). Annually 120.6 millions of sweetpotatoes are produced in the world (FAO Stat.,2009).

Sweetpotato cultivars are rich in dietary fibre, minerals, vitamins and antioxidants, including anthocyanins, phenolic acids, beta-carotene and tocopherol (Bengtssona et.al., 2008; Kim et al., 2007; Van Jaarsveld et al., 2006; Tokuşoğlu et.al., 2005, 2003; Yildirim et.al., 2011).

Sweetpotato contains high concentration of phenolics, that have been reported to have potential for consuming as a functional food for improving human health. It has been reported that sweetpotato phenolics were found to inhibit the growth of human colon, leukemia and stomach cancer cells (Kurata et al., 2007), to inhibit growth of viruses and fungi in vitro (Peterson et al., 2005) and to ameliorate diabetes in humans (Ludvik et al., 2008).

The purple and orange fleshed sweetpotatoes contain large amounts of anthocyanin and beta-carotene, respectively. Especially anthocyanin phenolics and carotenoids provide sweetpotatoes with their distinctive flesh colours containing cream, deep yellow, orange and purple and they act as antioxidants (Bengtssona et.al., 2008; Van Jaarsveld et al., 2006; Tokuşoğlu et.al., 2005, 2003; K'osambo et al., 1998; Woolfe, 1993). Color and variety can influence levels and profiles of phenolics as well as of anthocyanins (Steed & Truong, 2008) and carotenoids (Van den Berg et al., 2000). It has been reported a high content of anthocyanin pigments in the tuber of purple sweetpotato cultivars and it was stated that the anthocyanins from purple sweetpotato are more stable than those other plants which are purple-red color (Bolívar and Louis, 2004).

Several studies have been conducted on the antioxidant activity of sweetpotato extracts (Rumbaoa et.al., 2009; Teow et al., 2007; Huang et.al., 2006; Kano et.al., 2005; Oki et al., 2002). It was also reported that most anthocyanidins; pelargonidin, cyanidin, delphinidin, peonidin, petunidin, and malvidin, and their glycosidic forms (anthocyanins) acted as strong antioxidants.

The objectives of the study were to determine the anthocyanidin content and antioxidant activity of local Turkish sweetpotato variety Hatay Kirmizi (Hatay Red) grown in the Aegean Region of Turkey and to detect the boiling, steaming effects on its anthocyanidins and antioxidant activity levels.

MATERIALS AND METHODS

Chemicals

2,2-diphenyl-1-picryl hydrazyl (DPPH) (Cas Number: 1898-66-4), cyanidin-3-glucoside (Cas Number: 7084-24-4) were obtained from Sigma–Aldrich (St. Louis, MO,USA). All other reagents and solvents were of analytical and HPLC grades.

Sweetpotato Material

A local sweetpotato [Ipomoea batatas (L.) LAM] cultivar selected in Hatay Province of Turkey and named as Hatay Kirmizi (Hatay Red) was used as genetic material in a study conducted in the Department of Field Crops of the Aegean University (Yildirim etal., 2011). The tuber samples of Hatay Kirmizi used in this study were taken from the field testing trial harvested in November, 2004 and the storage root samples were used in anthocyanin and antioxidant activity analyses

Preparation of Sweetpotatoes to Phenolic Analysis

Eight storage roots were used for all analyses. Sweetpotato powder (equivalent to 250 mg of flesh weight) was extracted with 2.5 mL of an 80% ethanol solution (n=2). The supernatant obtained by centrifugation (4000 × g, 5 min), at 4+1 °C. This final extract was used as the sweetpotato extract sample for antioxidant activity analysis (Main Phenolic Extract).

Total Anthocyanin Determination of Sweetpotatoes

Total anthocyanin content was determined by using the modified method given by Giusti and Wrolstad (2001). Each sample was prepared by diluting 1 ml of sweetpotato main phenolic extract with 20 ml of water. Then a 0.5 ml of diluted aliquot with 4 ml of methanol / 10 % aqueous formic acid (1:9 v/v). The absorbance of this final extract was read at 530 nm at spectrophotometer (SP300 Optima). The anthocyanin content was calculated on the basis of the following equation and determined as cyaniding-3-glucoside equivalent.

Anthocyanins content (mg/100 g of dry matter) = A × MW × DF × 100/ (ε × W)

where A = absorbance,

MW = molecular weight of cyanidin-3-glucoside chloride ($C_{21}H_{21}ClO_{11}$, 449.2),

DF = dilution factor,

ε = molar absorptivity (26,900),

W= sample weight (g)

Antioxidant Activity Analysis (DPPH; 1,1-diphenyl-2-picrylhydrazyl Radical Scavenging Activity) of Sweetpotatoes

DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging activity was determined according to the modified method of Masuda et.al (1992). Each main phenolic extract (0.5–10 mg/ml) in methanol (2 ml) was mixed with 2 ml of freshly prepared methanolic solution containing 80 ppm of DPPH radical. The mixture was vortexed left to stand for ½ hour in the dark. The absorbance of the final solution was measured at 517 nm. The percentage of DPPH scavenging activity was calculated according the formula givin below:

[1-(absorbance of sample/absorbance of blank)] × 100 formula.

A lower absorbance indicates a higher scavenging effect. EC_{50} value (mg/ml) is the effective concentration at which DPPH radicals were scavenged by 50%. The results were expressed as cyanidine-3-glucoside equivalent.

Heat Treatment Effects

Sweetpotato samples were heat-treated as boiling, steamed and frying at controlled conditions. In all heat treatments, for temperature detection, termocouple Testo 922 Dual Input Type K Thermocouple (Brandt Instruments, Inc., LA, USA) was used. In all cooking process, same water type (Erikli, pH 7.25) was used. pH controlling was performed by using Testo-206PH1 Tds. After all heat treatments, samples were equilibrated to room temperature (25 ±1 °C) Ice bath (4±1 °C) was put under the samples for quick equilibration to 25 ±1 °C owing to the preserve the antioxidants of heat-treated sweetpotatoes (HTSP). Then HTSPs analyzed for antioxidant activity and anthocyanin analysis.

Boiling Process; 2 cleaned sweetpotato storage roots of Hatay Kirmizi same size were boiled in a stainless steel pan (Edition, TEFAL) containing boiled water more than its half and cooked during 12 min at medium heat. The remaining water of boiled sweetpotatoes was removed by a slotted spoon and equilibrated to 25 ±1 °C and preparation to analyses**.**

Steaming Process; 2 cleaned storage roots of sweetpotato cultivar Hatay Kirmizi were steamed by special steamer **(**VC 1002 Ultra Compact Steamer, TEFAL). 1/3 proportion of water **(**Erikli) was put into the water chamber of steamer whereas ¾ tea cup olive oil (Tariş Naturel Sızma**)** was put into the oil chamber of steamer and sweetpotatoes were steamed during 25 min. Steamed samples were equilibrated to 25 ±1 °C and preparation to analyses.

Frying Process**;** 2 cleaned sweetpotato storage roots of Hatay Kirmizi in same size were fried by using a frying oven (MF-26 GR Midi Oven, Vestel). Sweetpotatoes were put into the oily oven tray with ¾ tea cup olive oil (Tariş Naturel Sızma). Sweetpotatoes were fried during 5 min at 180 °C oven. The remaining oil of fried sweetpotatoes was

removed by a blotting paper, equilibrated to 25 ±1 °C and preparation to analyses.

Statistical Analysis

Statistical analyses were conducted by using the SAS version 9.1 (SAS, 1988). Significant differences between each parameters including anthocyanin level and antioxidant activity level were determined by the Duncan's Multiple Range Test (Steel and Torrie, 1980). The differences were considered to be significant at the $p < 0.05$ level.

RESULTS AND DISCUSSION

Total Anthocyanin Levels of Sweetpotatoes

Total anthocyanin level as cyanidin-3-glucoside equivalent (mg/100g) was provided. The calibration graph of standard cyanidin-3-glucoside is shown in Figure 1. The equation was found as $y= 0.0113x+ 0.0045$ ($R^2 = 0.9986$)

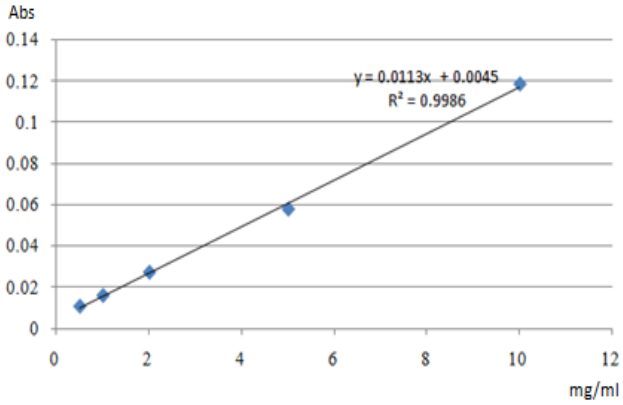

Figure 1. Anthocyanin standard (cyanidin-3-glucoside) calibration graph

Anthocyanin level of sweetpotato cultivar Hatay Kirmizi (as cyanidin-3-glucoside (C3G) equivalent) was determined as 11992 ± 15.86 mg/100g ($p\leq0.05$) (n=8). This indicated a mean around 120 mg anthocyanin for per g in our samples. Anthocyanins were detected 13767 ± 8.94 mg/100g; 38734 ± 6.70 mg/100g; 6755 ± 10.22 mg/100g in boiled, steamed and fried sweetpotatoes, respectively ($p\leq0.05$) (Table 1; Figure 2.)

Table 1. The means of the total anthocyanin levels measured in the samples of the yield trial run in 2004.

Total Anthocyanin as Quality Characteristic				
Hatay Kirmizi	**Raw mg/100g**	**Boiled mg/100g**	**Steamed Mg/100g**	**Fried mg/100g**
	11992± 15.86^{c}	13767± 8.94^{bc}	38734± 6.70^{a}	6755± 10.22^{d}

*** Means with different letters are significantly different at the $p\leq0.05$ level.

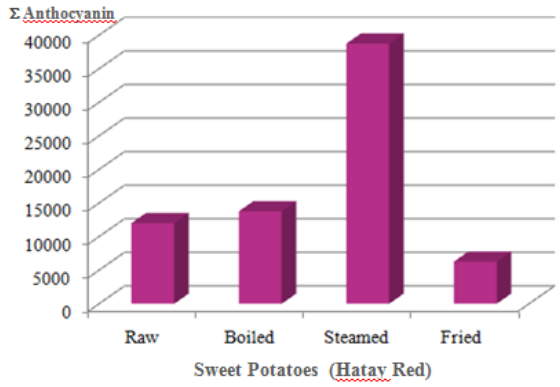

Figure 2. Total Anthocyanin Levels of Raw and Heat-Treated Sweetpotato Cultivar Hatay Kirmizi

Table 1 and Figure 2 show anthocyanin levels of sweetpotato cultivar Hatay Kirmizi. It was stated that total anthocyanins rised as 1.14 fold after boiling process effect, increased 3.22 fold after steaming effect whereas decreased 1.78 fold after frying effect ($p\leq0.05$). It was shown that steaming process, was the most effective among the heat-treated sweetpotatoes (HTSPs) (Table 1, Figure2).

Antioxidant Activity Levels of Sweetpotatoes

Antioxidant activity levels were determined for raw, boiled, steamed and fried sweetpotatoes (Table 2).

Table 2. The antioxidant activity levels measured in the samples of the yield trial run in 2004.

Antioxidant Activity as Quality Characteristic				
Hatay Kirmizi	**Raw** %Inhibition	**Boiled** %Inhibition	**Steamed** %Inhibition	**Fried** %Inhibition
	78.76^{c}	89.67^{b}	97.92^{a}	57.89^{d}

*** Means with different letters are significantly different at the $p\leq0.05$ level.

Antioxidant activities of heat-treated sweetpotatoes (HTSPs) were 78.76%, 89.67%, 97.92% and 57.89% (as radical inhibition percent), respectively. Among the heat treatments applied, especially with using steaming process, radical inhibition percent increased 1.24 fold.

With the steaming application during 25 minutes, tissues of the sweetpotato storage root can rupture and thereafter release more antioxidant constituents. In this context, it could be said that the advisable healthy cooking method for sweetpotato could be first steaming and then boiling. Since to sweetpotato is nutraceutical food for nutrition, it was shown that fried sweetpotatoes also have a good radical inhibition %, means that have an good antioxidant activity level (Table 2, Figure, 3).

Tubers of sweetpotato Hatay Kirmizi can be consumed not only in steamed > boiled > fried forms but can also be processed into food products, such as muffins, cookies, biscuits, noodles, breakfast foods and pies, with longer shelf-life, and improved characteristics.

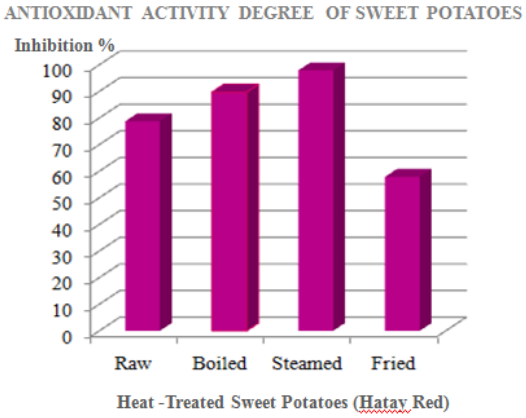

Figure 3. Antioxidant Activity Levels of Raw and Heat-Treated Sweetpotato Cultivar Hatay Kirmizi

Sweetpotato cultivar Hatay Kirmizi can also be processed into flour, that is less bulky and more stable and this sweetpotato tuber flour can be used as a thickener, antioxidant enhancer and color source in industrial powder soups, gravy, extruder snacks, and some bakery products.

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