Journal of Experimental Food Chemistry
ISSN: 2472-0542

Hossain et al., J Exp Food Chem 2019, 5:1

Research Article Open Access

Study on the Physicochemical Composition and Antioxidant Properties of Selected Colored Sweet Potato Variety (*Ipomoea batatas L*) in Bangladesh

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Received date: August 25, 2019; **Accepted date:** September 9, 2019; **Published date:** September 17, 2019

Abstract

Physio Chemical Characteristics of BAU Horticulture Garmcenter post harvested anti-oxidant enriched three colored varieties Sweet potato such as Yellow, Orange and Purple flash were selected for this study. The sweet potato were of various flesh colors which included orange, yellow and purple with dry matter content ranging from 30.3 to 34.5. The selected varieties varied significantly ($p<0.05$) in total solid 34.5 ± 0.57, 30.3 ± 0.36, and 33.35 ± 0.27; sugar content 10.61%, 10.54%, and 11.82%; protein 2.48 ± 0.50%, 2.38 ± 0.00%, and 2.17 ± 0.40%; fiber 1.98 ± 0.74%, 1.86 ± 0.43%, and 1.88 ± 0.44%; total carotenoid compounds 389.22 ± 2.18 µg/g, 138.96 ± 7.54 µg/g, and 116.28 ± 1.80 µg/g per 100 g respectively. Total Phenolic content of the selected varieties are 12.69 ± 0.3 mg, 16.89 ± 0.8 mg and 21.10 ± 1.11 mg per 100 g, as antioxidants. For orange fleshed sweet potato cultivar, the intensity of yellow color of dried sweet potato powders were higher than that of purple color dried samples. The orange color was more enhanced by freeze drying as confirmed by higher (a*) 24.93 ± 1.56 and (b*) ± 0.53 mg gallic acid/100 g DW values indicating deeper orange color. The pH of starch from the selected sweet potato varieties ranged from 6.10 to 6.33. The results revealed the influence of variety on the chemical composition of sweet potato starch properties. The objectives for analysis of different physio chemical properties evaluate its nutritional activity in human body including antioxidants.

Keywords: Sweet potato; Physio chemical properties; Carotenoids; Polyphenol; Dry matters

Introduction

The sweet potato is very high in nutritive value and merits wider use on this account alone. Contrary to popular opinion, it is not a starchy food when roasted or backed, since most of the starch is broken down to maltose and other soluble sugars. They rank as one of the healthiest vegetables, because of high levels of vitamin A, C, iron, potassium, anthocyanin, polyphenol, and fiber. They are also an excellent source of the vitamin A precursor, beta-carotene. Popular Crop genetic diversity is shaped by complex interactions between natural processes and those driven by humans. Primary centers of diversity occur in areas where the plant was domesticated. Here, diversity is generated by long periods of interaction between humans and their plants, often with continued gene flow with the crop's wild relatives. Secondary centers of diversity occur in areas where the crop was introduced. In these areas, despite bottlenecks associated with introduction, the shorter period of cultivation and the usual absence of wild relatives, crops have produced huge diversity in a short time. Sweet potato (*Ipomoea batatas*) is one of the most important tuber crops root crops that belong to the Convolvulaceae family. More than 130 million tons of sweet potato are produced annually of which over 95% of the crop is produced in Asia developing countries. The sweet potato has become well established with a large potential for, and to be used as a staple food in developing nations due to its short maturity time, ability to grow under diverse climatic conditions and relatively poor soils [1]. Fresh sweet potato roots are bulky and perishable, its need to fully utilize the indigenous crops. One of the good methods to minimize postharvest losses is through processing sweet potato's tubers into flour, starch, dry pellet, and making them become the more stable intermediate product to increase the consumption of the easy cultivated fresh crops [2].

Sweet potato flour can be added to natural sweetness, color, and flavor to food products and used as starting material for the production of biscuits, ethnic food, chips, dry French figure, sweetmeat, noodles, bread, snacks, beverages, etc. [3]. Orange, yellow, purple sweet potatoes and the derived starch were the common subjects of the studies have also been done so far [3,4]. Sweet potato tuber flesh can be either white, cream, yellow, orange, or purple [5] but the most commonly grown and eaten are orange, white, and cream. Sweet potatoes are an important staple crop in parts of Africa, Asia, and the Pacific [6]. Sweet potato roots have remarkable pro-vitamin A quantities and they are one of the major food sources of carotenoids [7]. Carotenoids are the natural organic molecules with diverse and important biological actions an functions, sources from the plant. Carotenoids participate in the process of photosynthesis for pigments synthesis; also in protecting chlorophylls from photodamage. Beta carotenoids type play pro vitamin A precursors in the human body as antioxidants, and other carotenoids are associated with the prevention of cancer and other chronic diseases. Fruits and vegetables are an important source of carotenoids for the human food as prime sources; about 70-90% consumed carotenoids [8] in every day's food intake of the human being. Carotenoids act as antioxidants, created more attraction to the researchers from various fields including biochemistry, biology, food science and technology, medicine, pharmacy, and nutrition for a long time. Carotenoids are widely distributed natural pigments responsible for the yellow, orange, and purple colors of fruits, roots, flowers, fish, invertebrates, and birds [9]. The major carotenoids important to humans are β-carotene, lycopene,

lutein, zeaxanthin [10]. These compound have biological properties of interest for humans, and or nutritional properties to remove malnutrition due to its anti-oxidant properties. Ingested with food, these compounds strengthen our natural protection against oxidative stress and thus prevent various chronic diseases such as cancer as well as cardiovascular diseases [11]. Since they cannot be synthesized by the human body, these pigments have to be supplemented through the dietary intake [12] rich source in sweet potato. In Bangladesh, cream color sweet potato is most popular among local poor farmers, but there is an urgent need to determine their nutritional value and also study its nutritive properties. The aims of the present study are to analysis physic-chemical properties, determination of carotenoids and anthocyanin's content in locally produced sweet potato to identify potential utility for the agro-food processing industries.

Materials and Methods

Materials

Three types of verities Amélia (yellow sweet potato), Peru (purple sweet potato), and Beauregard (orange sweet potato) were analyzed in this current study. Samples were cultivated on the experimental BAU Germplasm field of the temperature (31° 38'S; 52° 22'W; altitude 7 m). Planting was carried out in the first half of January 2015, using seedlings with high fertility, obtained from vegetative multiplication of matrices derived from the summer/rainy culture. After three months, the Sweet potatoes were collected and stored under refrigeration, between 5°C to 8°C, for six months. Raw sweet potato samples were blanched in de-ionized water at 95°C for 2 min.

Heating plates were employed, using glass beakers with a raw material and water mass ratio of (1:10). The blanched material was frozen at -77°C for 30 min, so that their geometric center reached -40°C, in an ultra-low freezer, Therefore, a rapid freezing rate (approximately 2°C/min) was used to promote the formation and distribution of small ice crystals, and to minimize tissue damage and drip loss during thawing. Frozen material was stored at -18°C for 1-15 days in the freezer prior to starting freeze-drying. For the analysis, frozen samples were thawed at 8°C for 18 hours in a home refrigerator in order to avoid and prevent the icing damage. The samples were washed to remove clay, peeled, cut into slices, freeze-dried (EYELA FDU-1100, Japan) for 105 hours, then the samples were ground into a fine powder and kept at -20°C until analysis.

Methods

Freeze drying methods: Freeze drying (FD) was performed in a laboratory-scale Armfield FT-33 freezedryer (Armfield Ltd., England). In the freeze drying process, the Sweet potato samples were spread uniformly in a single layer on a stainless steel tray. The samples (100 g) were frozen at -21°C in a freezing/heating chamber and freeze-dried to a moisture content of 4%–5.5% (w.b.) at an absolute pressure of 70–130 Pa with a cabinet temperature of 20°C and a freezing chamber temperature of -40°C. Thermocouples of freeze drier were inserted into the sweet potato slices. The weight loss of the samples was followed by a data logger and an RS-232 attached to a PC computer, acquired the data readings from platform cell, which is placed within the sample chamber.

Water activity (aw): The water activity (aw) can be bonded the water in the food material. Low aw foods are those with activity levels lower than 0.8. Therefore, the targeted aw of dried sample was 0.6, the general level limits for the growth of yeast, molds, and bacteria [13]. Approximately 10 g of chopped dried sweet potato samples were placed in the sample holder of a Novasina Labmaster (model CH-8853, Novasina AG, Switzerland) aw meter. The temperature and required time for testing were at 25°C and 30 min.

Rehydration capacity process: The rehydration characteristics of the dried material are always used as an index of structural quality, and it largely depends on the dehydration conditions employed [14]. The measurement of the water rehydration ratio was based on the following procedure. 100 ml of distilled water was brought to a temperature of 22°C in a constant temperature water bath. Then a precisely weighed 0.5 g sample of the freeze-dried material was placed in a plastic vessel and immersed for 25 and 50 min. afterward, the samples were taken out and blotted with tissue paper to eliminate excess water on the surface. The weights of dried and rehydrated samples were measured having a sensitivity of 0.1 g.

Sugar analysis of sweet potato: The method used to analyze for the sugars was a modification of that described by Knudsen. 1.0 gm Selected processed sweet potato powder Samples were extracted with Ethanol-Mille Q water (1:3 v/v) for 12 hours, and the extract was mixed by electric mixer machine for 45 minutes. The extract was centrifuged at 2200 Xg for 30 minutes before 2 ml of an internal standard was added to 4 ml of the extract. The extract was purified using C-18 cartridges (Water Corporation, Milford, Massachusetts, USA), which had been washed with 2 ml of methanol and 5 ml of Mille Q water. It was further filtered through a 0.2 µm filter (Pall Life Sciences, 600 South Wagner Rd, USA), taken to dry under vacuum at 50°C (Vortex-Evaporator, H. Haake Buchler Product, Saddle, NJ, USA) and 20 µl used to determine the concentration of sucrose using spectroscopy.

Dry matter content and pH: The dry matter content of the sweet potato roots was determined using the oven method (Gallenkamp, UK) by drying 2 g of fresh sweet potato sample at 100°C overnight following standard procedures [15]. pH of the sweet-potato flour was determined using a pH meter (PHM 92, Radiometer, Copenhagen Denmark) after standardizing with buffer solutions of pH 4 and 7.

Color measurement: Color of Sweet potato samples was measured, in L*a*b* system, using a Minolta Chroma Meter (Minolta Corp, Japan). Parameters L*, a*, and b* determine a three-dimensional color space, in which L* represents brightness (on a lightness–darkness scale) whereas positive and negative a* values determine the redness and greenness; positive and negative b* values determine yellowness and blueness, respectively. The instrument was calibrated against a white-standard. The individual differences in L*, a* and b* values from the zero-time readings were combined to obtain a total color difference (DE) using the following equation:

$$\Delta E=\sqrt{(lo-l)^2+(ao-a)^2+(bo-b)^2}$$

Where, l0, a0 and b0 represented the readings at zero time, and L*, a*, and b* represented the readings at each time intervals for each time. A larger DE denotes a greater color change from the reference material.

Extraction of carotenoids: The extraction procedure essentially follows the methods described by Othman et al. [16], with some modification. 1.0 g of each powdered freeze-dried sample was weighed and rehydrated with 3 mL of distilled water, then extracted in 25 ml of acetone and methanol mixture (7:3) containing calcium carbonate. The samples were mixed well with continuous shaking by an agitator and

placed overnight in darkness at room temperature with covering dark paper. After aging, the sample was vortexed and centrifuged for 2 minutes at 13500 rpm for good separation of the desired extracted materials in the elute (Thermo Scientific, Sorvall Biofuge Primo R, Germany) and the filtered extructed supernatant solution was collected and transferred to a foil covered 50 ml centrifuge tube. The pooled supernatant extracted solutions were centrifuged to remove unexpected particles and stored at -20°C in the darkroom for analysis. Then, an equal volume of hexane and distilled water was added to the extracted supernatants solutions. The mixture was allowed a few times to separate under centrifugal force. The collected upper phase then dried for a long time under a gentle stream of oxygen-free nitrogen [17].

Determination of total carotenoid content: The total carotenoid concentration of all sweet potato extracts was determined by spectrophotometry according to the method described by Othman and Lewis et al.

The dried carotenoid was re-suspended in 300 µl of ethyl acetate for determination of total carotenoid content. 50 µl of the re-dissolved sample was then diluted with 950 µl chloroform for spectrophotometric analysis. The carotenoid-containing solutions were measured at three different wavelengths λ; 480 nm, 648 nm and 666 nm using (Varian Cary 50 UV-Vis) spectrophotometer.

Statistical analysis: Data analyses were determined using the PASW Statistics 18 software (IBM Corp., USA), and analyses of variance were conducted by ANOVA procedure, Duncan test. Mean values were considered significantly different when $P<0.05$. The parameters of model were calculated using data.

Results and Discussion

Analysis of proximate attributes for selected Sweet Potato samples of freeze dry powders are presented in Table 1. Sweet potato flesh tubers varieties from orange, yellow, and purple types were selected for this study, showing the proximate values with carotenoids contents in Table 1. The moisture contents of orange, yellow and purple sweet potatoes were 7.14 ± 0.01, 7.02 ± 0.08, 6.45 ± 0.03%; protein contents were 2.48 ± 0.50, 2.38 ± 0.00, 2.17 ± 0.40%; Fiber content was 2.1 ± 0.00, 2.4 ± 0.00, 2.34 ± 0.00% ; Carbohydrate was 86.86 ± 0.44, 85.80 ± 0.61, 85.80 ± 0.61% respectively. Results revealed that the highest total carotenoid content was observed in the yellow-fleshed sweet potato (138.96 ± 7.54 µg/g DW). Purple and Orange-fleshed accumulated almost the same amount at 116.28 ± 1.80 µg/g DW and 115.18 ± 5.71 µg/g DW respectively. These three types of different flesh color exhibited highly significant differences in total carotenoid content ($P<0.01$). There was a strong relationship between total carotenoid content and the color intensity of colored sweet potato tuber flesh. These results are in agreement with the previous reports where orange-colored sweet potato cultivars were found richer in carotenoids value than yellow, and purple sweet potato varieties as shown in Figure 1.

Parameters	Orange	Yellow	Purple
Moisture	7.14 ± 0.01	7.02 ± 0.08	6.45 ± 0.03
Ash	1.98 ± 0.74	1.86 ± 0.43	1.88 ± 0.44
Protein	2.48 ± 0.50	2.38 ± 0.00	2.17 ± 0.40
Fat	0.44 ± 0.19	0.50 ± 0.30	0.55 ± 0.46
Fiber	2.1 ± 0.00	2.4 ± 0.00	2.34 ± 0.00
Carbohydrate	86.86 ± 0.44	85.80 ± 0.61	85.80 ± 0.61
Total Carotene , µg/g DW	389.22 ± 2.18 µg/g	138.96 ± 7.54 µg/g	116.28 ± 1.80 µg/g

Table 1: Proximate analysis of selected three varieties of coloured sweet potato dry powder.

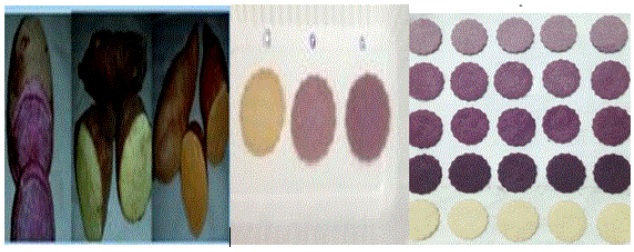

Figure 1: BAU purple, yellow and orange color sweet potato.

In Table 2, shows that freeze drying process required the longest drying time (22 h, 27 h, and 25 h), due to freeze drying, under vacuum conditions, supplies the sublimation heat by conduction. The findings revealed the rate of heat transfer slower than heat transfer methods, dehydration takes a long time.

Freeze drying of sweet potato	Method final moisture content		Total drying time (h)	(h) Reduction in freeze drying time (%)
	w.b (%)	d.b (%)		
Purple	5.78	0.151	22	0
Yellow	5.67	0.142	27	0
Orange	5.55	0.149	25	0

Table 2: Effect of drying on moisture content using freeze drying technology.

Table 3 shows the Sucrose content was the major sugar in all the sweet potato varieties with values ranging from 10.96 to 11.89%; dry matter was 30.3 ± 0.36 to 34.5 ± 0.57 and pH 10.54 to 11 in all the three sweet potato varieties with values. In the data dry basis and weight basis moisture contents are shown in respect the the rate of dehydration of three types sweet potato sample. Different dry solid, sucrose content and pH values were investigated using AOAC methods shown in the graphical presentation.

Sweet potato varieties	Dry matters (%)	pH Value	Sucrose (%)
Orange	34.5 ± 0.57	6.33 ± 0.020	10.61
Yellow	30.3 ± 0.36	6.02 ± 0.021	10.54
Purple	33.35 ± 0.27	6.10 ± 0.010	11.82

Table 3: Physical profiles (dry mater, Sugar, pH) of sweet potato varieties.

In the same row, means followed by the same superscripts or capital letters are not significantly. The difference among samples (P>0.05) according to Fisher's least significant difference (LSD) procedure are presented into the table. Table 4 represents the color values (Hunter L* a* b*) of color sweet potato powder samples. Freeze drier was used for dehydration of the samples. For orange-fleshed sweet potato cultivar, the intensity of the yellow color of dried sweet potato powders was higher than that of purple color dried samples. The orange color was more enhanced by freeze-drying as confirmed by higher a* and b* values indicating deeper orange color. This was the result of higher β-carotene retention in freeze-dried sweet potato powders. However, the samples appeared lighter after drying as observed from higher L* and lower a* values compared to the fresh sample. Higher in the lightness of powders increased after drying treatments for all samples was due to the inhibition of polyphenol oxidase. Also, higher a* and b* values which indicated yellow, orange color in the fresh sample were recorded higher β-carotene content. Significant decrease in a* and b*values of powders indicated loss of yellow and red color due to the effect of heat treatments. For purple-fleshed sweet potato cultivar, Freeze drying significantly ($p<0.05$) increased the purplish color of the sweet potato powder observed from an increase in the negative (–) b*value. This result was consistent with the higher anthocyanin content in the dried powder. Truong et al. reported that cyanidin and peonidin contribute to the blue and red hues of purple-fleshed sweet potatoes [18]. In another study, the scientist reported that Potato powder pretreatment with steaming before drying was due to the formation of polymeric anthocyanin and some non-enzymatic browning pigments [18].

Varieties of sweet potato	Color			Total phenolic content (mg gallic acid/100 g DW)
	L*	a*	b*	
Orange	74.22 ± 0.54	27.93 ± 0.56	44.44 ± 0.53	12.69 ± 0.3
Yellow	54.40 ± 0.32	24.33 ± 0.22	24.04 ± 0.77	16.89 ± 0.8
Purple	34.94 ± 0.86	24.83 ± 1.41	21.01 ± 0.32	21.10 ± 1.11

Table 4: Color composition of selected sweet potato samples.

For each cultivar, the total phenolic contents of sweet potato samples after heat treatments were noticeably higher than that of raw samples (on dry basis) as shown in Table 1. The results are in agreement with other studies [19] who reported that phenolic contents were affected by cooking processes such as steaming, boiling, and drying was shown in Figure 2. The Variation in total phenolic contents as per heat treatment to drying conditions were observed. Thermal processing abruptly enhanced the total phenolic contents of the sweet color potato powders. For freeze-dried samples had the highest phenolic content due to higher time in respect to vacuum processing. The observation in this study was confirmed [20-22], pointed out that steam treatment enhanced the total phenol contents of sweet potato genotypes.

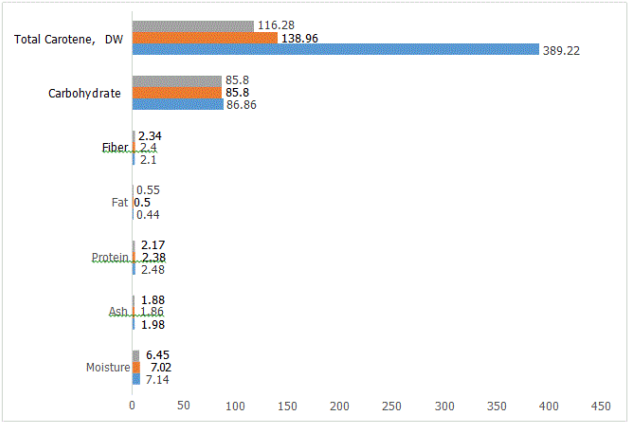

Figure 2: Proximate values of colored sweet potato verities.

Conclusion

In this study, new information on total carotenoids, anthocyanin, polyphenols, availability with the cheapest price and quantified its nutritional values and importance's to overcome the vitamin A deficiency diseases was investigated. Due to its bright color, nonpoisonous nature, rich nutrition, safe and health care function, carotenoids from colored sweet potato are recommended for applications in neutraceutical supplements, food and cosmetic industries locally and globally. The composition of sweet potato varieties ; chemical and functional properties of freeze dried starch of selected three types sweet potato varieties indicate possible variations in the suitability of processing of these types. Colored sweet potato varieties contains starch, fiber, carotenoids, polyphenol, protein, which can be used as raw materials of bakery products, snacks, and colorants and antioxidants. These results will therefore be useful in showing possibilities of using colored sweet potatoes diversely in the food processing industry to enrich value added micronutrients fortified products to remove malnutrition.

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