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Research Article

Effect of Treatment on the Beta Carotene Retention of Orange Fleshed Sweet Potato Varieties Grown in Hawassa, Ethiopia

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ABSTRACT

Background: Vitamin A Deficiency (VAD) is a public health problem in Ethiopia. It affects vision, growth, tissue differentiation and immune system. Orange-Fleshed Sweet Potato varieties are known to contain high amount of β-carotene and other carotenoids.

Objective: This study was designed to determine β-carotene retention of Orange-Fleshed Sweet Potato varieties and to investigate the effect of treatment methods on its β-carotene content of Orange-Fleshed Sweet Potato varieties that were collected from Hawassa Agricultural and Research Institute.

Methods: Six treatment methods including boiling, steaming, microwave cooking, oven drying, sun drying and post steam-drying were simulated in the study to check their effects on the True Retention of β-carotene. Compared to boiling, steaming resulted in much more loss of β-carotene and microwave cooking resulted in the biggest loss of β-carotene among the six treatment methods.

Results: The results showed that β-carotene contents were significantly affected by many factors, and this was demonstrated using the varietes of Kulfo and Tulla. β-carotene contents in Orange-Fleshed Sweet Potato, six treatment methods including boiling, steaming, microwave cooking, oven drying, sun drying and post steam-drying were simulated in the study to check their effects on the True Retention of β-carotene. Compared to boiling, steaming resulted in much more loss of β-carotene and microwave cooking resulted in the biggest loss of β-carotene among the six treatment methods. The level of retention was significantly different ($P<0.05$) among treated orange fleshed sweet potato.

Conclusion: Orange-Fleshed Sweet Potato should be prepared for consumption, using methods that protect the loss of β-carotene content which helps Orange-Fleshed Sweet Potato as a staple food as well as a snack food for supplying vitamin A for both rural and urban populations.

Keywords: Vitamin A Deficiency, β-carotene, Retention, Orange fleshed sweet potato

INTRODUCTION

Vitamin A Deficiency (VAD) predisposes an estimated 100 million Africans to a higher risk of visual impairment and blindness (African Union, 2005). Vitamin A Deficiency is a serious public health problem in Ethiopia. National prevalence rates of 1.7 % for bitot's spots and 0.8% of night-blindness among children and 1.8% for night-blindness among mothers are reported. Nationally, 37.7% of children had deficient serum retinol levels [1].

Sweet potato varieties, especially Orange-Fleshed Sweet Potato (OFSP) varieties, contain significant amounts of β-carotene, starch, dietary fiber, minerals, vitamins (especially vitamins C, B6 and folate), as well as antioxidants, such as phenolic acids, anthocyanins, and tocopherol [2]. The composition and contents of nutrients in sweet potato varieties vary greatly; depending on genetic and environmental factors. Foods from plant origin are an important source of pro-vitamin A in developing countries [3].

OFSP is naturally a bio-fortified crop and it has great potential to be used in food-based intervention programs to address Vitamin A Deficiency. The crop is a promising solution to Vitamin A Deficiency because it is rich in β-carotene and substantially better absorbed than other leaves and vegetables [4]. Among the ways to

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incorporate OFSP to foods, its flour appears to be the most effective way for increasing the vitamin A content of OFSP enriched food products [5].

The efficacy of β-carotene rich OFSP variety in preventing Vitamin A Deficiency (VAD) has been demonstrated in primary school children from South Africa [6]. It is reported that β-carotene rich OFSP can make a major contribution in alleviating vitamin A malnutrition in Sub-Saharan Africa [7]. Also, the incorporation of OFSP in meals eaten by 3 to 6 years old Indonesian children, marginally deficient in vitamin A, increased serum retinol concentrations [4].

Therefore, it is important to quantify the losses of provitamin A carotenoids during processing of orange fleshed sweet potato. Thus, the present study was designed to determine β-carotene retention of treated food (boiling, steaming, microwave cooking, sun drying, oven drying, and post steam-drying) of Orange Fleshed Sweet Potato varieties (Kulfo and Tulla). In addition, functional property and better retention with time and temperature variation was determined.

MATERIALS AND METHODS

Study area

Orange Fleshed Sweet Potato: Samples of two orange fleshed sweet potato varieties used in this study were taken from Hawassa Agricultural Research Center, Ethiopia. Samples were collected from farms at Hawassa site. The varieties, grown for 22 to 24 weeks, were selected based on availability. For each variety, 8 kg roots were harvested, placed in a cardboard box and transported to Addis Ababa University (AAU) laboratory, Centre for Food Science and Nutrition. The roots were stored at temperature of -25 °C in refrigerator and β-carotene analyses were carried out. Two commercially released orange flesh sweet potato varieties (Kulfo and Tulla) were used for the present study.

Laboratories: The study was conducted at Addis Ababa University (AAU), Centre for Food Science and Nutrition laboratory, Ethiopian Food, Medicine and Healthcare Administration and Control Authority laboratory and Ethiopian Public Health Institute laboratory.

Chemicals and standards

All solvents used in the analysis of carotenoid were HPLC grade. The solvents used were acetone, PE, acetonitrile, methanol, ethyl acetate, triethylamine and n-hexane. An analytical grade standard of beta-carotene was used to calibrate and quantify beta-carotene. All chemicals and reagents used for laboratory analysis of other parameters were analytical grade.

Method of analysis

Sample preparation of raw roots for β-carotene analysis: This is to measure the content of β-carotene in the two orange fleshed sweet potatoes, two medium-sized sweet potato roots (300-350 g) from each variety were quartered longitudinally from the stem end to the root end, washed with tap water and a brush, and blotted with tissue paper. The two opposite quarters from each root were selected and the peel removed, cut into cubes of ca 2 × 2 × 2 mm and mashed with a porcelain pestle [8].

Preparation of cooked roots for β-carotene analysis: Boiling and steaming, microwave oven cooking, steam-dried chips, oven and sun drying for each (boiling, steaming, microwave oven cooking) method of cooking, two medium-sized roots of two orange fleshed sweet potatos were washed with tap water and a brush, blotted with tissue paper, peeled, and then cut into 1 × 1 × 1 cm cubes and mixed well. Six portions of samples of 25 g were weighed and used for boiling as well as steaming [8].

Beta Carotene Analysis

Standard preparation and calibration: The standard was prepared by using crystal form of 95% HPLC grade beta carotene type II from sigma aldrich. stock solution was prepared 10 mg in 100 ml n-hexane. All calibration points were prepared from stock standard solution through a serial dilution to be 0.25-5.0 µg/ml in n-hexane. A 7 point calibration curve was plotted from 0.25 to 5.0 µg/ml. The calibration curve was linear (r^2=0.998).

RESULTS

Beta carotene in orange fleshed sweet potato varieties: In the raw peeled samples of two orange fleshed sweet potato varieties, β-carotene was the most abundant provitamin A carotenoid. The β-carotene content in the raw, peeled samples Kulfo and Tulla was found 400 µg/g and 335 µg/g, respectively.

Beta-carotene in orange fleshed sweet potato varieties is presented in the following tables. All values done in fresh weight and values are represented as means ± SD in duplicate determinations.

DISCUSSION

Root crops have pro-vitamin A proved to be an effective means to alleviate Vitamin A Deficiency [9,10]. The present study revealed the difference of β-carotene level in OFSP varieties. As shown in Table 1 in duplicate determinations, the β-carotene content in the raw, peeled samples Kulfo and Tulla was found 400 µg/g and 335 µg/g, respectively. These beta carotene results are different from findings reported by other researchers in which β-carotene content of sweet potato ranging between 0.01 and 26.6 mg/100g (fwb) and 11.8 mg/100 g respectively [11-13].

This study is in line with studies conducted in some countries in which deep orange colored sweet potatoes β-carotene content ranged between 4.29 and 18.55 mg/100 g, 0.009 and 20.525 mg/100 g in orange variety in South Africa [14] and 9.230 mg/100g for the main USA variety Beauregard [15].

On contrary, other researchers reported low values as compared to those obtained in this study. For instance β-carotene content of 0.254 ± 3.84 and 0.181 ± 2.64 mg/100 g for Ejumula and Kakamega verities have been reported respectively [3].

OFSP can provide up to 6.528 mg/100 g [16] and β-carotene of sweet potato varieties ranging between 1.68 and 1.85 mg/100 g [17]. The literature data led to the conclusion that, in the OFSP, there are high as well as low values of this nutrient, and are all determined by varieties.

Results indicated that the orange fleshed varieties varied in their β-carotene content and retention capabilities. In the raw, peeled samples of two orange fleshed sweet potato varieties, β-carotene content was high. However, β-carotene content in the different

varieties varied greatly, the highest β-carotene content was found in the variety Kulfo whereas a lowest amount was found in Kulfo variety as shown in Table 1. This indicates that the β-carotene content in the same variety of sweet potato is influenced by many factors, such as growing conditions, climate, soil type, sunlight, processing and stage of maturity.

Table 1: β-carotene content of fresh OFSP Kulfo and Tulla varieties grown for 20-22 weeks in Hawassa, Ethiopia, 2017.

Orange Fleshed Sweet Potato varieties	β-carotene content (µg/g fresh peeled weight)
Kulfo	400 ± 0.42
Tulla	335.25 ± 0.07

In a research conducted in Sub-Saharan Africa, B-carotene content of medium-sized OFSP from the same harvest batch ranged from 132 to 194 mg/kg fresh weight [6]. The β-carotene content in the raw, peeled samples Kulfo and Tulla was found to be 400 ± 0.42-334.05 ± 0.35 µg/g and 335.25 ± 0.07-280 ± 0.28 µg/g weight, respectively. This variation in β-carotene content may be due to differences in varieties, growing conditions, stages of maturity, harvesting and post-harvest handling, processing and storage of OFSP, air and soil temperature, radiation, location, soil moisture and fertilization [10,18-20]. Furthermore, environmental conditions, genetic factors, crop age and cultivation management strategies can significantly influence the β-carotene content of varieties [18].

Cooking and processing have a degrading effect on β-carotene content. Sun drying was observed to retain 63-73%, oven drying 89-96%, boiling 84-90% and frying 72-86% β-carotene in OFSP varieties studied (17) and boiling retained 70-80% of the vitamins [6,20].The influences of different processing procedures on the carotene content of orange-fleshed roots have been reported in sweet potato, carrots, and cassava respectively [20]. In general, retention of beta-carotene content decreases with long processing time, high temperatures, cutting and maceration of food [10,14]. Some of the sweet potato varieties indicate that cooking has an effect on β- carotene content. Carotenoids cannot be biosynthesized during cooking [10]. Heat treatment inactivates enzymes responsible for carotenoid biosynthesis and stimulates isomerization and oxidative degradation of carotenoids.

In similar manner, effect of boiling for both varieties indicated that a decrease in β- carotene content was positively related to the duration of boiling Kulfo and Tulla varieties. The true b-carotene retention decreases as time of boiling is increased as shown in Table 2. Boiling for 50 min resulted in a decrease of about 50% of the β-carotene content, whereas boiling for 10 min resulted in a highest retention of β-carotene (Table 2). Some studies show that results a 14-59% reduction in the content of total carotenoids in unpeeled, whole medium-sized sweet potato roots from four cultivars boiled for 30 min [18].

Table 2: Effect of boiling time on the carotene content of the OFSP Kulfo and Tulla varieties grown for 20-22 weeks in Hawassa, Ethiopia, 2017.

Orange Fleshed of Sweet Potato varieties	B-carotene content (µg/g fresh peeled weight)	Boiling time (min)	β-carotene content (µg/g) boiled, peeled	True retention β-carotene (%)
Kulfo	381.85±1.90	10	371.05 ± 0.63	97.1
		20	368.15 ± 1.06	96.4
		30	317.45 ± 0.07	83.1
		40	255.2 ± 2.68	66.8
		50	217.9 ± 0.56	57
Tulla	303.65±0.63	10	294.5 ± 2.40	96.9
		20	279.9 ± 1.13	92.1
		30	232.65 ± 0.77	76.6
		40	210.3 ± 0.42	69.2
		50	181.45 ± 1.06	59.8

Moreover, the effect of steaming on β-carotene content of sweet potato can lead to a reduction in the β-carotene content. Results showed that the decrease in β-carotene content was positively related to the duration of steaming, decreasing by about 5.7%-45.7% and 3.2%-45.7% when steamed for 10 to 50 min for Kulfo and Tulla varieties (Table 3). The decrease in the content of β-carotene was larger with steaming than boiling.

Table 3: Effect of steaming time on the β-carotene content of the OFSP Kulfo and Tulla varieties grown for 20-22 weeks in Hawassa, Ethiopia, 2017.

OFSP Varieties	B-carotene content (µg/g fresh peeled weight)	β-carotene content (µg/g fresh peeled weight) steaming time (min)	β-carotene content (µg/g) steamed, peeled	True retention of β-carotene (%)
Kulfo	345.3±1.13	10	325.85 ± 0.49	94.3
		20	277.6 ± 2.12	80.3
		30	260 ± 1.83	75.2
		40	231.6 ± 0.28	67
		50	187.8 ± 2.61	54.3
Tulla	288.05±1.06	10	278.9 ± 1.27	96.8
		20	264.75 ± 2.19	91.9
		30	201.65 ± 2.05	70
		40	176.25 ± 0.21	61.1
		50	156.15 ± 2.05	54.3

On the other way, microwave oven cooking on β-carotene content. This method is fast and the loss of nutrients during microwave cooking is perceived to be minimal showed that the reduction in β-carotene content was positively related to the duration of microwave cooking (Tables 3).When compared with boiling and steaming, microwave cooking resulted in the largest reduction in TR of β-carotene 44.2% and 23.5% in Kulfo and Tulla varieties respectively.

CONCLUSION

The effect of oven drying on β-carotene content showed reduction in β- carotene content which is 3.2% and 7.4% respectively. This study also revealed that the effect of sun drying on β-carotene content and the result showed reduction in β- carotene content was 20.9% and 22.4%, respectively.

Moreover this study showed the effect of steaming and drying of chips on β-carotene content in which the reduction in β- carotene content was 6% and 12.8% after drying at 50°C for 5 h respectively and after drying for an additional period of 6 hrs (to remove the remnant water), the reduction in β-carotene content was 21.8% and 39.6% which was the reduction more than tripled.

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