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Orange fleshed sweet potato a nutrition sensitive functional food for possible dietary approach to vitamin A deficiency and undernutrition

Jyotsna Khanam [1], Sheikh Faisal Asadullah Mahdi [2], Monera Ahsan [2] and Sheikh Nazrul Islam [1,*]

[1] *Institute of Nutrition and Food Science, University of Dhaka, Dhaka 1000, Bangladesh.*
[2] *Department of Clinical Pharmacy and Pharmacology, Faculty of Pharmacy, University of Dhaka, Dhaka 1000, Bangladesh.*

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Abstract

Orange Fleshed Sweet Potatoes (OFSPs) is an excellent nutrition sensitive function food. It contains dense amount of carotene and is also rich in proximate nutrients. A wide number of cultivars of OFSPs has been developed worldwide, particularly in sub-Saharan Africa and Asia. In Bangladesh, sixteen cultivars have been developed. Carotene content in the OFSPs surpasses all of the plant food carotene. OFSPs also contains good content of energy yielding nutrients. The Orange Fleshed Sweet Potatoes could, therefore, be a potential dietary approach to address the vitamin A deficiency for undernourished indigent people.

Keywords: OFSPs; Carotene; Pro-vitamin A; Proximate

1. Introduction

1.1. Nutrition sensitive food system

Nutrition sensitive food aims to improve human nutrition. The degree of s achieving sensitivity depends on how it complies with other food system as explained by the Influences on food consumption figure. In *nutrition sensitive* system, policies for dietary diversity are requisite to improving nutrition in poor countries, where economy is based on agriculture and consumption of macro- and micronutrients may be below the required demand [1].

In order to achieve nutrition sensitive food, nutrition-sensitive agriculture policy is to be adopted to address the determinants of malnutrition and child development, involving agriculture, health, social protection, early child development, education, water and sanitation, and women's affairs targeting to those most vulnerable to malnutrition. It also includes the design and implementation of nutrition-based approaches to sustainable farming and cropping systems aimed at improving the nutritional outcome of a population. Agriculture and food systems have a critical impact on nutrition outcomes at the national macro- and micro-level among communities, households and individuals. Agriculture and food sectors will have to ensure adequate supplies of high quality and safe foods for consumers and for markets.

* Corresponding author: Sheikh Nazrul Islam
Institute of Nutrition and Food Science, University of Dhaka, Dhaka 1000, Bangladesh.

1.2. Influences on food consumption

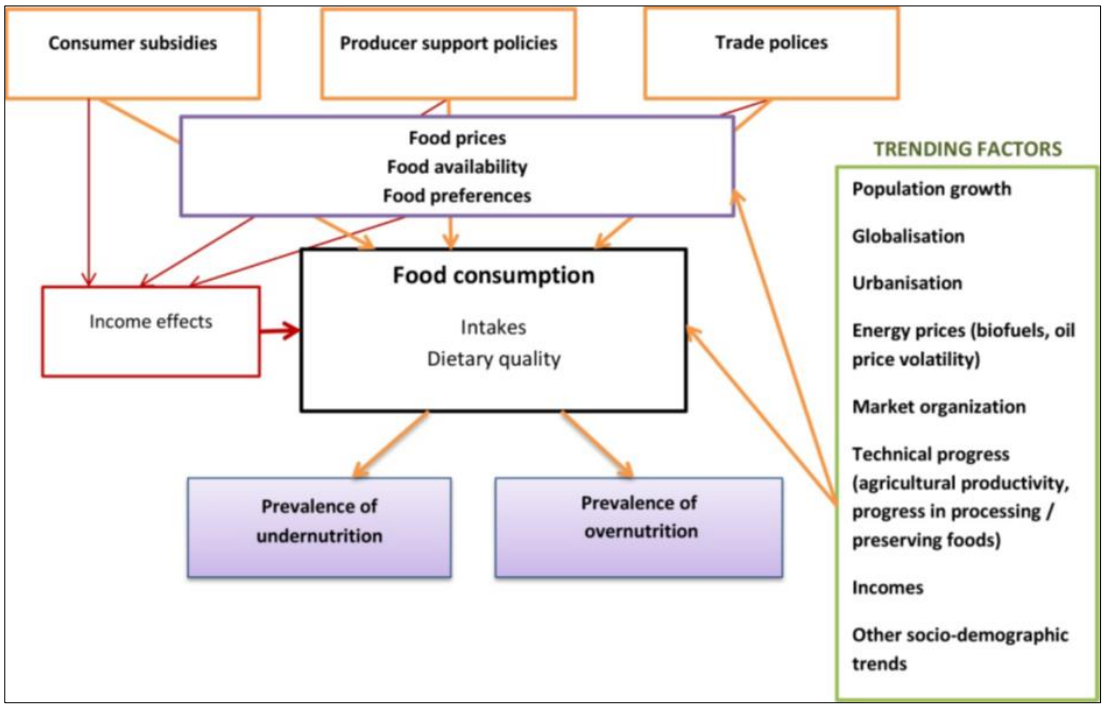

Figure 1 Trending factors for food consumption

1.3. Orange-fleshed sweet potatoes

The sweet potatoes (*Ipomoea batatas* L. *Lam.*) belong to the Morning glory family of *Convolvulaceae* [2]. It has treasured medicinal properties having anti-cancer, antidiabetic, and anti-inflammatory activities [3]. In 2007 HarvestPlus through the Consultative Group on International Agricultural Research (CGIAR) Program on Agriculture introduced the potato for nutrition and health. In Bangladesh, potato is the fourth most important crop after rice [4], which are enriched with dietary fiber and micronutrients including vitamin C and potassium [5,6]. It ranks highest in nutrition per *kilojoules*. It contains the highest carotene of all plant products; even higher than the carrot [7]. OFSP is biofortified sweet potato that enrich its β-carotene, the pre-cursor to vitamin A. A 100 g of OFSP can meet the daily vitamin A needs of a young child [8].

Currently, wide varieties of micronutrient rich sweet potatoes are growing in the world including Bangladesh. Nine verities have grown in Bangladesh [4], and recently seven more cultivars with added desnse β-carotene have been introduced.

1.4. Carotenes in OFSP

Carotenes are natural pigments, responsible for orange-yellow-red color and flavor in fruits, vegetables, and flowers [6]. In addition to β-carotene, OFSP contains high amount of α-carotene, β-cryptoxanthin, anthocyanin, lutein and zeaxanthin, which contribute its flesh color into orange, purple, jewel, garnet, and red [9,10]. Carotene exists as *trans*- and *cis*-isomers rise [11].

The β-carotene- provitamin A is converted into retinol in small intestine, also in liver and kidney [12]; one molecule β-carotene is converted into two molecule vitamin A. It is a safe source of vitamin A; does not make hypervitaminosis in excess intake.

Thermal processing increases the bio-accessibility of β-carotene of OFSP. Boiling increases *cis*-β-carotene and decreases *trans*-β-carotene. It is because of isomerization of *Trans* to *cis* isomer [11].

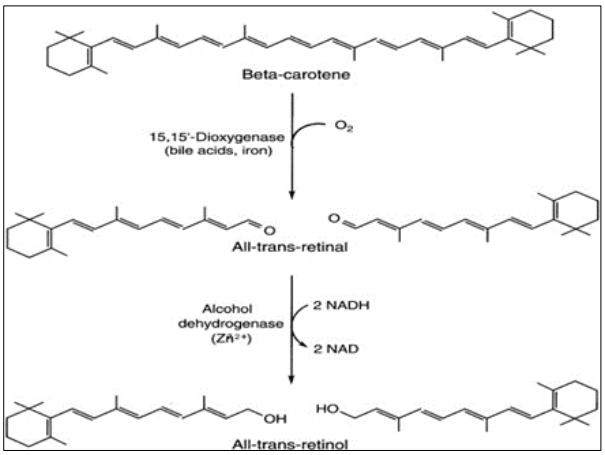

Figure 2 Conversion of beta carotene to retinol

1.5. OFSPs and Vitamin A deficiency

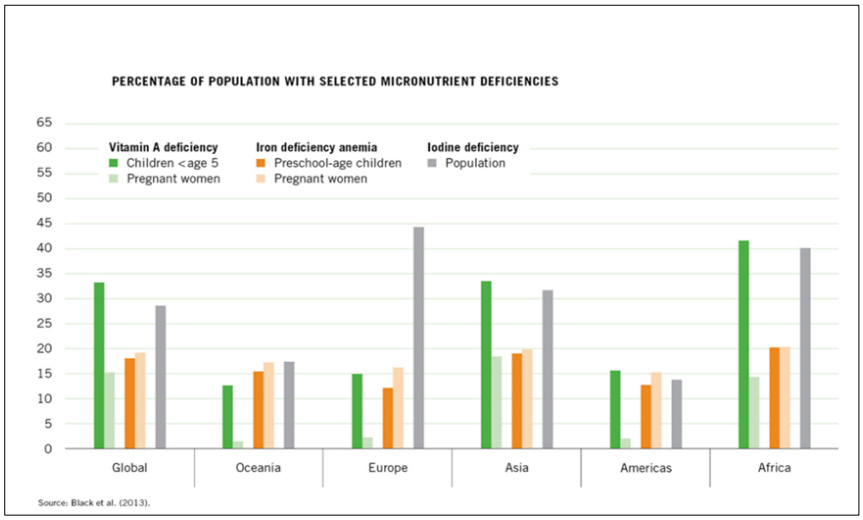

Figure 3 Micronutrient deficiency in different groups of population

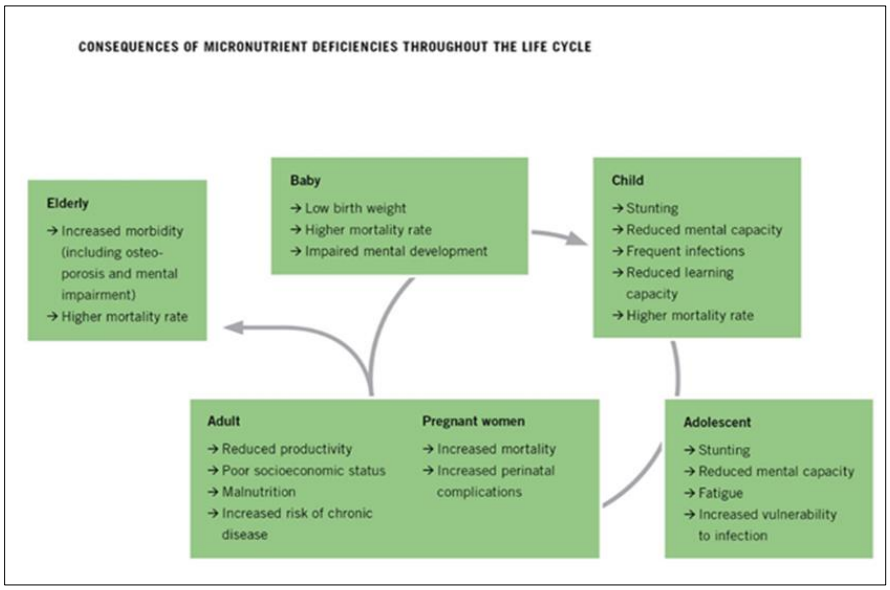

Figure 4 Micronutrient deficiencies throughout the life cycle [17]

Hidden hunger or micronutrient deficiencies afflicts more than 2 billion people in the world [13], effects of which can be devastating, leading to mental impairment, poor health, low productivity, even death. Its adverse effects on child health and survival are particularly acute, especially within the first 1000 days of a child life, resulting in serious physical and cognitive consequences. Too low micronutrient intake or absorption impairs sustaining health and development in children and mental function in adults [14].

The provitamin A rich OFSP can address the life-threatening vitamin A deficiency disorders. It has been using in the sub-Saharan Africa, to combat the vitamin A deficiency. About 43 million <5 years children, 90 million preschool children and 19 million pregnant women are affected by vitamin A deficiency [8,15,16] in sub-Saharan Africa. Vitamin A deficiency is contributing to high rates of blindness, disease and premature death in children and pregnant women. It also induces immunodeficiency disorder. The Micronutrient deficiency, although mostly affects the pregnant women, children, and adolescents, it impairs the health throughout the life cycle.

1.6. OFSPs in Food Security

Adequate nutrition makes healthy growth and development, inadequate contributes child mortality. Nutrition sensitive food system aims to improve human nutrition, and the degree of sensitivity obtained depends on compliance of food system priorities, entailing behavioral responses by consumers, producers and traders. In food system, policy and promotion of dietary diversity is essential to improving nutrition in low-income countries.

"Food and nutrition security exists when all people, at all time, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active, productive and healthy life". It also stands obtaining adequate quality dietary varieties.

It is documented that one billion people are being affected by nutrition insecurity, particularly in sub-Saharan Africa, where potato and OFSP are being used as staple food. Sweet potato fights poverty and malnutrition for millions of people. Because of high yield, less production time, and high nutritional value, millions of people consume OFSP to promote their food security. The International Potato Center (CIP) has developed many improved varieties of sweet potato, including 104 OFSP varieties. Sixteen varieties of OFSP with rich carotene have been developed in Bangladesh. In addition to be the excellent source of β-carotene, minerals and vitamins, the OFSPs also contain a plenty of energy yielding proximate nutrients. Thus, it could also combat malnutrition or undernutrition. Carotenoids or carotene, because of its strong antioxidant, anti-inflammatory, immune enhancing potentials, has been reported to be preventive in chronic degenerative diseases [18-20]. It is being used and contributed a significant role in combating energy and vitamin A deficiencies, especially in sub-Saharan Africa

2. Material and methods

2.1. Analysis of Carotene

Sixteen cultivars of carotene rich OFSP has developed in the Tuber Crops Research Centre (TCRC) of Bangladesh Agricultural Research Institute (BARI), Gazipur-1701, and Bangladesh. Some of the varieties contain extreme dense content of carotene, even, higher than the carrot. This study reports proximate and carotene contents of new seven varieties of OFSPs.

2.2. Sampling

The OFSP samples (table 1) were collected from harvesting ground of TCRC, BARI. The potatoes were grown in the same cultivation practice and condition, and harvested when become matured. The samples were processed, cut, packed and stored at -20^{o}C for analysis of proximate composition and carotene.

The color of OFSPs were diverse and distinct (Table 1), which depend on the intensity of carotenoids or carotene. The higher the carotene content was found, the deeper was the colour, as it was observed in other varieties of OFSPs [11] and in some minor indigenous fruits like Monkey jaks, Magosteem, Roselle [21].

Table 1 Characteristics of orange-fleshed sweet potatoes investigated

Sl no	Common name	Flesh colour	English name	Source
1	BARI SP 10	Cream	Orange Fleshed Sweet Potato	Tuber Crops Research Centre (TCRC), Bangladesh Agricultural Research Institute, BARI
2	BARI SP 11	Deep Cream		
3	BARI SP 12	Orange		
4	BARI SP 13	Deep orange		
5	BARI SP 14	High deep orange		
6	BARI SP 15	High deep orange		
7	BARI SP 16	Deep orange		

2.3. Analysis of proximate nutrient

Proximate nutrients were analyzed by AOAC methods as described by Hossain et al [22]. In brief, moisture was estimated by heating the sample at 100-105^{o}C to constant weight; protein content was determined with Micro- Kjeldahl method; fat amount was assessed by $CHCl_3$-CH_3OH extraction and dry-ash method was used to determine ash content. Carbohydrate value was calculated by difference, where moisture, protein, fat, ash and fiber contents were subtracted from the total weight of sample.

2.4. Analysis of carotene

Carotene was determined by cool acetone-petroleum ether (Merck, Darmstadt, Germany) extraction using a spectrophotometric method using extinction coefficient for β-carotene [11, 23].

The method validation and data quality were made by in-lab and inter-labs analysis, data were found approximately same ($p>0.05$).

SPSS and Microsoft Excel 2013 were used for statistics.

3. Results and discussion

The proximate composition in the OFSPs was described in table 2. Average moisture content ranged from 70.80%±0.4 % and 78.29%±0.68 %, which was found same as claimed by Alam et al [4] for the other varieties of OFSPs. However, BARI SP 15 and 16 contained much higher moisture. It is reported that Yam (elephant) contained about 98.7% moisture [24]; it indicated that the solid content in OFSPs tested was around 29 to 21 %, which is less than staple grains such as rice, wheat, maize, and carotene rich carrot [24]. The protein values varied from 2.03%±0.12% to 3.15%±0.3%; the highest content (3.15%±0.32%) was in the BARI SP 15; which is higher than yam, similar to BARI SP 9, or much less than BARI SP 4 and 8 [4,24,25].

Table 2 Proximate nutrients (g/100 g) of OFSP with peel

OFSP Varieties	Proximate composition					
	Moisture	Protein	Fat	Ash	Crude fiber	Carbohydrates
BARI SP 10	70.799±0.4	2.936±0.02	0.522±0.02	0.876±0.03	0.45±0.04	24.867±0.922
BARI SP 11	73.281±0.25	2.727±0.025	0.887±0.03	0.893±0.02	0.385±0.02	21.827±0.47
BARI SP 12	71.392±0.35	2.905±0.1	1.127±0.025	1.323±0.02	0.49±0.025	22.763±0.73
BARI SP 13	71.695±0.6	2.721±0.082	0.902±0.01	1.208±0.05	0.58±0.04	22.894±0.302
BARI SP 14	70.763±0.56	2.831±0.04	0.584±0.025	1.026±0.05	0.33±0.03	24.466±0.87
BARI SP 15	76.854±0.72	3.154±0.32	0.625±0.025	1.368±0.03	0.52±0.06	17.479±1.0
BARI SP 16	78.291±0.68	2.038±0.12	1.068±0.03	1.228±0.01	0.42±0.015	16.955±0.56

OFSP: orange-fleshed sweet potato

This revealed that OFSPs growing in Bangladesh contains high protein content. Fat content was ranged from 0.52±0.21 to 1.13±0.02 g per 100 g OFSP, which was noted to be higher than the reported other OFSPs [4]. This might be due species or cultivar variation.

Carotenoids are plenty in orange-yellow-green fruits and vegetables. Table 3 shows the total carotene or carotenoids content in the recently grown varieties of OFSP. The carotenoid content ranged from 357.048 ± 28.78 to 8299.92±136.97 μg/100 g fresh weight, which is incredibly high as reported for BARI SP 8 or the Kamalsundari BARI SP 2 varieties grown in Bangladesh [4]. High content of carotenoids has also been reported for the OFSPs grown in India and Brazil [9,26]. Some vegetables such as Carrot, Banchalta, Coriander, Spinach sour, Taro green leaves also contain a good amount of carotenoids [24]. Therefore, the OFSP containing dense carotene may be a possible diet for vitamin A deficiency as well as for under-nutrition [27].

4. Conclusion

OFSP contains a rich amount of carotene, particularly the BARI SP 14,15 cultivars along with high calorie nutrients. This could be one of the best possible dietary approaches to vitamin A deficiency and under nutrition for the resource deprived poor people.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest in this research and publication.

Authorship

JK and SFAM carried out the experiment, interpret results and wrote primary draft. MA assisted in result interpretation manuscript preparation. SNI designed, supervised, facilitated research facilities and edited the manuscript to make it final.

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