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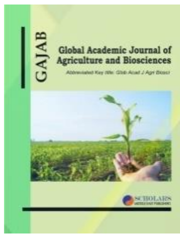

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Review Article

Major Nutritional Content of Orange Fleshed Sweet Potato (OFSP) and It's Importance: Review

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Abstract: Sweet potato is playing an immense role in human diet and considered as second staple food in developed and developing countries. Its production and management need low inputs compared to the other staple crops. The natural nutritional content of sweet potato roots varies up on the flesh color the contain. Thus, Orange-fleshed sweet potatoes are one of the richest natural sources of beta carotene, a plant-based compound that is converted to vitamin A in your body so as to combat malnutrition, including vitamin A deficiency. In addition to beta- carotene, OFSP is known as a source of dietary fiber, complex carbohydrates, proteins, vitamins A, C, and B, iron, calcium as well as the making of industrial starch and leaves also could be consumed as vegetables. A 100-150 g serving of boiled roots of orange-fleshed sweet potato can supply the daily requirement of vitamin A for young children which can protect them from blindness. Along with the β-carotene, the pro-vitamin A, the young children and adults can also get adequate number of calories, vitamin C and other micronutrients through increased consumption orange-fleshed sweet potato. Therefore, sweet potato an important crop in the economic uplifting of humans and serving as both food security crop and nutrition security crop.

Keywords: Anti-oxidant, Beta-carotene, Carbohydrate, Minerals, Starch, Vitamin A deficiency.

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1. INTRODUCTION

Sweet potato (*Ipomoea batatas*) is an important root crop belonging to the Convolvulaceae family. Its origin is in Mexico and Venezuela in the Central or South Americans continent. Sweet potato has become the 3rd largest cultivated root crop after potato and cassava globally based on its nutritional and agronomic resilience and food security properties (Neela and Fanta, 2019). Today, sweet potato is cultivated in over 120 countries worldwide (Sugri *et al.*, 2017) with over 133 million tons of annual production. Continentally, Africa and Asia are the leading producers of sweet potato with 95% of production coming from developing countries, bringing sweet potato to the 5th and 6th important food crop respectively in developing countries and in the world. In terms of production, China is the leading producer, followed by Nigeria and Tanzania, Indonesia, and Uganda (FAOSTAT, 2019). International Potato Center (2017) reported that sweet potato is 3rd vital food crop in seven central and eastern African countries, 4th priority crop in six South African nations, and 8th in four West African countries. Sweet potato is a key conventional crop, growing traditionally in limited area for domestic consumption purpose. It is considered as a "poor man's" crop as it characteristically grown and consumed by meager communities especially by women-headed families (Githunguri and Migwa, 2004; Ndolo *et al*., 2001). Sweet potato considered as the food security crop due to its low agriculture input requirements and high yields in wider climatic conditions (Ziska *et al*., 2009). SP crop is recently changing from a sustainable low-input, low-output crop to a significant cash crop. As a food security crop, it can be harvested at the point of demand as gradually (Tairo *et al*., 2005).

Orange fleshed sweet potato (OFSP) is nutritionally an important source of beta-carotene, a precursor of vitamin A, vitaminsB6, and C (Robertson *et al*., 2018). Orange fleshed sweet potato (OFSP) is essential in combating malnutrition, including vitamin A deficiency. A 100-150 g serving of boiled tubers of orange-fleshed sweet potato can supply the daily requirement of vitamin A for young children which can protect them from blindness (Tsou and Hong, 1992). Along with the β-carotene, the pro-vitamin A, the young children and adults can also get adequate number of calories, vitamin C and other micronutrients through increased consumption orange-fleshed sweet potato. Moreover, OFSP is a source of dietary fiber, complex carbohydrates, proteins, vitamins A, C, and B, iron, calcium as well as the making of industrial starch (Korada *et al*., 2010; Baba *et al*., 2018). Leaves are consumed as vegetables in some communities (Masumba *et al*., 2007). Sweet potato helps in the economic uplifting of humans and serving as a food security crop. It maintains healthy blood pressure, prevents constipation due to its high fibre content, has anti-cancer agents, reduces the risk of obesity, diabetes, heart disease, and overall mortality in humans (Anderson *et al*., 2009) and serve as a liver purification crop. The high fibre, phytochemicals, and iron content in sweet potato promote fertility in women (Slavin and Lloyd, 2012). Sweet potato contains a low glycaemic index scale, regulates blood sugar level and insulin resistance in diabetic patients, and thus serves a homeostatic property in human health. The glycaemic index of sweet potato reduces the risks of stroke by 24% (Zuo *et al*., 2019). Reports on the OFSP incorporation in staple foods and its role in national food security and well-being are readily available. Therefore, due to many positive aspects related to agriculture, nutritional security and food security different researches are intensified on OFSP to increase its production and consumption in different countries. Therefore, the objective of this paper is to review the major nutritional composition of orange fleshed sweet potato and its importance in different aspects.

2. Major Nutrition Content of Orange Fleshed Sweet Potato

2.1. Dry Matter

Sweet potato storage root dry matter content is defined as the remaining part of the edible root after draining away completely its water. In sweet potatoes, carbohydrates constitute most of the dry matter (Picha, 1987). The author also added that in sweet potato carbohydrates accounts about 80-90% of the dry matter content, and finds in the form of sugars and starch (Mcharo and La Bonte, 2007) non-starch polysaccharides. Dry matter content varies depending on the cultivar, cultural practices and climate and ranged from 13-14%. The most quantitatively important component of dry matter of storage root of sweet potato is starch (Woolfe, 1992) and accounts about 60-70% of total dry matter content (Rodrigues *et al*., 2016). So, OFSP can consume as the staple crop because of high concentration of carbohydrates (Jobling, 2004). Starch in sweet potato expressed in the form's amylose and amylopectin and their ratio also varies between cultivars (Dansby and Bovell-Benjamin, 2003). The non-starch polysaccharides were classified as cellulose, hemicelluloses and, pectic substances, which are found in the middle lamella (Dansby and Bovell-Benjamin, 2003). These are also referred to as dietary fiber and play an important role in the sweet potatoes nutritional value. The pectic constituents play also a key role in textural attributes in the storage root utilization, including moistness, dryness or firmness.

The dry matter content is a good selection index for traits such as cooking quality and starch content in root and tuber crops. According to Woolfe (1992), positive and highly significant correlation (r=0.926) was found between dry matter and starch content for Taiwanese sweet potato genotypes, indicating that starch content can be assessed through storage root dry matter content. Therefore, for achieving high dry matter content, the accumulation of genes controlling high starch content is recommended (Lebot, 2008). In Japan, the strategy used for accumulating genes controlling starch content was inbreeding in self-compatible clones and sib mating (Lebot, 2008). A high starch is a preferred attribute of the low sugar, staple types which generally the most cultivated in the tropics (Mwanga *et al*., 2007). High heritability for dry matter content was reported including 75-88 % (Zhang and Li, 2004), 69.84 % (Tsegaye *et al*., 2007) and 64 % (Jennings, 2009). High variation was also reported in the trait, ranging from 14% to more than 44% in sweet potato genotypes. Therefore, with high heritability and huge genetic variation, quick progress can be achieved in breeding for high dry matter content.

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To quantify sweet potato dry matter, the most commonly used method is as follows: the fresh weight (about 200 g) of thinly sliced roots is measured, followed by oven-drying at 60 or 70 °C for 2–5 days. Then, dry-matter content is calculated by determining the fresh and dry weight, and estimating the percentage of dry weight (10). Root dry matter content (%DMC) = [(Dry weight/Fresh weight) x 100]

2.2. Sugars

Sugar is an indicator of sweet potato taste. Sweet potato cultivars with strong flavor and high levels of sweetness may have reduced its popularity as a staple food and made it difficult for combination with other foods in a variety of dishes (Woolfe, 1992). These factors play a significant role in reducing the esteem of sweet potato to end user. Sucrose, glucose, and fructose are major sugars occurring in raw storage roots of sweet potato. However, it has been reported low content of maltose in raw sweet potato storage roots (Van Den *et al*., 1986). Moreover, the most abundant sugar is sucrose (Van Den *et al*., 1986), and is found three times sweeter than maltose, while fructose and glucose are, respectively, 5 and 2 folds sweeter than maltose, with maltose seeming to be the most desired sugar by user used (Koehler and kays, 1991). In cooked roots, starch is hydrolyzed to produce maltose. About 42 to 95 % of the starch in several sweet potato varieties was converted during baking and that most (72–99%) of the converted starch accumulated as maltose (Walter, 1995). Baking converted more starch to sugars than boiling, but boiled roots were higher in percent total sugars, starch cellulose, and hemicellulose, and lower in water soluble pectin (Sistrunk, 1977).

The concentrations of sucrose, fructose, and glucose depend on the type of cultivar, and can account for as much as one-half of the perceived sweetness of a cooked sweet potato (Woolfe, 1992). The author also stated that sweet potato contains many enzyme systems, which catalyze individual synthetic and degradative processes within the tissues, and alpha- and beta amylases are the most important enzymes in both cooked and processed roots. Varieties that are sweet types have high enzyme activity, while those with low-sweet have low enzyme activity (Morrison *et al*., 1993). Flavor (sugar and aroma) analysis involves the measurement and evaluation of the sensory characteristics of the cooked product, typically using a descriptive test with trained panelists. Picha (1985) developed the HPLC technic for sugars quantitative analysis in raw and baked sweet potato storage roots, but the procedure is tedious and expensive method (Takahata *et al*., 1993). In addition, refractive index and near-infrared transmittance (Katayama *et al*., 1996) were the other procedures of sugar determination that have been used. Significant advances have been made in recent years, in the precision of quantitative measurements for individual beta-carotene and sugars in the sweet potato crop. These include both Near infrared reflectance Spectroscopy (NIRS) and Nuclear magnetic resonance (NMR) spectroscopy. NIRS technique is well adapted to developing countries conditions, and can be used for the high-throughput screening of a large samples number (Jennings, 2009). It is a non-destructive method, rapid, and cost effective, permitting the simultaneous determination of major constituents in a mixture by multivariate data analysis.

2.3. Beta-Carotene

Carotenes are natural pigments, responsible for orange-yellow-red color and flavor in fruits, vegetables, and flowers (Neela and Fanta, 2019). 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 (Vimala *et al*, 2011). Carotene exists as trans- and cis-isomers rise (Islam *et al*., 2016). The β-carotene- provitamin A is converted into retinol in small intestine, also in liver and kidney (Tang, 2010); 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 (Islam *et al*., 2016). The provitamin A rich OFSP can address the life-threatening vitamin A deficiency disorders. Vitamin A is an essential nutrient though needed in small amounts by the human body. It plays a vital role in the normal functioning of the visual system, growth and development, and maintenance of epithelial cellular integrity, immune function, and reproduction (Mbela *et al*., 2018) Apart from preventing vitamin A deficiency, carotenoids rich foods protect human bodies against chronic diseases including cancers, cardiovascular disease, diabetes, cataracts, some inflammatory diseases, and age-related muscular degeneration due to their antioxidant properties (Englberger *et al*., 2003; Etcheverry *et al*., 2012).

Many researchers reported orange fleshed sweet potato had a significant BC concentration in fresh and dry basis. Tomlins *et al*. (2012) reported the highest range (20–364 (μg/g db)) of the BC in OFSP from different varieties grown in Uganda and Teow *et al*. (2007) also reported the 44.9–226 (μg/g fw) of the BC in fresh base from US varieties of OFSP. In general, beta- carotene is very high in OFSP compared to the common consuming yellow to orange vegetables and fruits. As reported by the Gul *et al*. (2015) the carotenoid concentration in different foods, such as carrot (43.5–88.4 μg/g), mango (10.9–12.1 μg/g), and tomato (2.17–2.83 μg/g), contain the lower concentration of the BC than the OFSP. Kim *et al*. (2015) reported 570 μg/g (db) of the carotenoids in OFSP, which are much higher than any other fruits and vegetables.

High-performance liquid chromatography (HPLC) is a method to determine beta-carotene in sweet potato. However, this method is tedious and (Takahata *et al*., 1993) developed a rapid method that links the color chart of OFSP and BC. Significant advances were reached in recent years, in the precision of quantitative measurements in sweet potatoes for individual beta-carotene and sugars. These advances include use of Near-infrared reflectance. Spectroscopy (NIRS) and Nuclear magnetic resonance (NMR) spectroscopy. Takahata *et al*. (1993) stated that sweet potato flesh color is significantly correlated with β-carotene, with the orange fleshed varieties being highest in β- carotene content (Takahata *et al*., 1993). Therefore, using a color chart developed at CIP, β-carotene concentration may be determined in the field (Gabriela *et al*., 2009). Because of the presence of minor carotenoids, spectrophotometry overestimates the HPLC values for beta-carotene content (Lebot, 2008). Near-infrared (NIRS) technique is good for improving the efficiency of breeding for crop quality (Starr *et al*., 1981). The NIRS analysis may be a relevant technique to determine simultaneously the concentration of beta-carotene, dry matter, starch, and sugar in sweet potato.

2.4. Minerals and Vitamin C

Minerals are desirable in human body for cellular activity of enzyme, nerve responses muscle contraction and blood clotting (Gupta, 2019). Foods rich in calcium are vital for bone health and development in infants (Loughrill *et al*., 2017). OFSP have iron, zinc, potassium, calcium, magnesium and phosphorus minerals with 0.63–15.26 mg/100 g, 0.24–0.93 mg/100 g, 15–51 mg/100 g, 24.40–45.54 mg/100 g, 3–37 mg/100 g and 15–51 mg/100 g respectively (Endrias *et al*., 2016; Lyimo *et al*., 2010; Nicanuru *et al*., 2015). Iron is an important component of hemoglobin (substance in the red blood cells that carries oxygen from the lungs to other parts of the body). Iron is a significant constituent of blood and enzymes involved for electron transfer, its deficiency can result in tiredness, weakness, anemia (McLaren, 2019 Zinc is a desirable mineral by pregnant women for safe baby delivery; it is use for body's defensive (immune) system, protein and nucleic acid synthesis, carbohydrate absorption and normal body growth. Potassium is important in regulating the body fluid balance required for the transmission of nerves impulse in the body (Zoroddu *et al*., 2019). High potassium intake is associated with lowering blood pressure and the effect of increasing potassium as an additive is to lower sodium intake. Potassium, calcium and magnesium had been associated to lower the rate of cardiovascular diseases (Parpia *et al*., 2018). Phosphorus also a necessary mineral in human body after calcium and possesses a pivotal role in abundant metabolic process, including energy metabolism and bone mineralization, and DNA and RNA framework (Karp *et al*., 2007).

Vitamin C naturally presents in two isomers as ascorbic and dehydroascorbic acid, and they are metabolites in various plants, animals, and fungi (Drouin *et al*., 2011). Vitamin C is known as one of the safest and most effective nutrients, and involves in immune system functions (Padayatty *et al*., 2003), cardiovascular disease (Simon, 1992), prenatal health problems, eye disease, and skin wrinkling. Vitamin C is extremely essential in synthesis of collagen (Varani *et al*., 2000), carnitine (Johnston *et al*., 1996), and neurotransmitters (Lee *et al*., 2001), and in the formation and maintenance of bone material (Wang *et al*., 1997), to fight against the oxidative stress (Bendich and Langseth, 1995). Adult men and women require 90 and 75 mg of the vitamin C as the RDA, respectively (Naidu, 2003). Grace *et al*. (2014) reported vitamin C concentration in OFSP as 870 μg/g (db) of ascorbic acid, which is very less than the different fruits and vegetables

3. CONCLUSION

Sweet potato is the second most important root crop and the seventh most important food crop of the world, although categorized as "poor man's food" or "famine crop". It has tremendous potential to contribute to the food security, to alleviate poverty and to supplement as an alternative staple food for the poor farmers, because of its diverse range of positive attributes like high yield with limited inputs, short duration, high nutritional value and tolerance to various production stresses. High levels of β-carotene, phenolics, anthocyanins, vitamins, fiber, dietary, minerals, and other bioactive compounds content depends on the flesh color of sweet potatoes. Orange fleshed sweet potato is a good source of the basic nutrients and different vitamins, minerals, polyphenols, antioxidants. It is known with high β-carotene levels and low dry matter content. Consuming β-carotene leads as a viable long-term food-based strategy for combating the deficiency vitamin A in the world.

Orange-fleshed sweet potato is now emerging as an important member of the tropical tuber crops having great possibility for being adopted as regular diet of the consumer food chain to tackle the problem of vitamin A deficiency. Thus, the poor people having only limited access to the expensive vitamin A rich animal foods like fish oil, egg, milk and butter, can meet the daily requirement of vitamin A along with some other essential nutrients through increased consumption of these roots. Being rich in β-carotene, a precursor of vitamin A, orange-fleshed sweet potatoes are now considered as an important biofortified crop in many developing countries in alleviating Vitamin A malnutrition and it also contain a plenty of energy yielding proximate nutrients. Thus, it could also combat malnutrition or undernutrition. In general, orange fleshed sweet potato has a great role in human diet and nutrition and has also a potential for animal feed. Therefore, production of this crop should be scale up as both food security and nutritional crop.

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