Vitamin A deficiency is caused by a habitual diet that provides too little bio available vitamin A to meet physiologic needs. 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. Apart from cheap source of energy, Orange-fleshed sweet potato is an excellent source of the β-carotene. This crop is also gaining importance as the cheapest source of antioxidant having several physiological attributes like anti-oxidation, anti-cancer and may help in protection against liver injury and coronary heart disease. Orange fleshed sweet potato is the most suitable as biofortified crop to combat micronutrient malnutrition in small and marginal farming community.

Keywords: orange fleshed sweet potato, vitamin A deficiency

Introduction
Vitamin A Deficiency is the most common cause of childhood blindness in the world (WHO, 2009) [62]. Children and pregnant women are more likely to suffer from vitamin A deficiency. The World Health Organization reported that vitamin A deficiency affects about 190 million preschool-aged children and 19 million pregnant women, mostly in Africa and South-East Asia (WHO, 2011) [60]. Nearly 44–50% of preschool children in South and Southeast Asia are affected by severe Vitamin A deficiency (Akhtar et al., 2013) [1]. Among the all South Asian countries, India has the highest prevalence of clinical and subclinical vitamin A deficiency, the prevalence being as much as 62% in preschool children (Suri & Kumar, 2015) [47]. In India, about 40,000 children are affected every year by blindness mainly due to the deficiency of vitamin A and nearly half of the world’s micronutrient deficient people may be found in this country (National Micronutrients Status Survey 2011–12, UNICEF, GAIN, & Nutrition 2013) [31].

Inadequate intake of vitamin A at this age can lead to vitamin A deficiency that, in turn, may cause night blindness, undermine growth and immune function. This also results in increased risk of morbidity and mortality, largely from measles, diarrhoea and respiratory infections (Sommer, 2011, WHO, 2011 and WHO, 2012) [46, 60, 61]. Children are at a higher risk of intestinal infestations and infections, which may also impair absorption of vitamin A (WHO, 2014) [63]. Breast milk is the only significant source of vitamin A for infants (Sommer, 2011) [46] and infants fed little or no breast milk in early life are increasingly susceptible to infections (Akhtar et al., 2013) [1]. Thus, vitamin A malnutrition is a major public health concern of the developing countries and is responsible for millions of deaths annually among the young children. The nutritionists in several developing countries compelled the evidence of lack of adequate essential vitamins and minerals in the diet of many children and adults (Sommer, 2011) [46]. Unlike those in developed countries, who receive abundant preformed vitamin A (retinol) from animal foods (liver, eggs, milk and milk products), whereas poor people living in third world countries rely on cheap dark green-yellow local vegetables and fruits for vitamin A. Vitamin A deficiency is caused by a habitual diet that provides too little bio available vitamin A to meet physiologic needs, rapid growth and frequent infections. An ineffective utilization of vitamin A is also critical factors for the vitamin A deficiency (Akhtar et al., 2013 and WHO, 2011) [1, 60].
Food Based Strategies for Improving Vitamin A Status

Despite the considerable efforts and investments put into tablet, capsule and injection based approaches, the significant progress on supplementation programs to reduce the magnitude of vitamin A deficiency in developing countries had not occurred over the past few decades. Although, some animal foods like fish oil, liver, egg and butter, rich in vitamin (retinol) are used directly and easily by the human body, but the poor people cannot afford these expensive foods. Considerable efforts are, therefore, to be made to promote vitamin A intake through increased consumption of cheap fruits and vegetables which although do not contain vitamin A as such but do contain its precursor, the β-carotene that can be converted to vitamin A by the human body. Supplementation programs in alleviating vitamin A deficiency, thus, will be replaced in future by sustainable food based strategies (Burri, 2011) [9]. One complementary approach to reducing vitamin A deficiency and other micronutrient deficiencies is to encourage shifts toward more micronutrient-dense diets (Ruel and Alderman, 2013) [40]. Among three different approaches, namely Vitamin A supplementation programme, fortification of common foods with micronutrients and the improvement of dietary quality through diversification of foods, the dietary diversification is an important food based approach in achieving and maintaining adequate intake of micronutrient-rich foods in the context of an adequate total diet (Islam et al., 2016) [19]. This food based approaches requiring an intersectoral perspective like providing agricultural and educational inputs with an awareness of cultural, socio-economic, market and health conditions may prove to be the most sustainable of the various interventions (Black et al., 2008) [6].

Sweet potato

Sweet potato (Ipomoea batatas L. Lam), the second most important root tuber and the seventh most important food crop of the world. Although, it is categorized as “poor man’s food” or “famine crop” but it has tremendous potential to contribute to a food based approach to promote food security, to alleviate poverty and to supplement as an alternative staple food for the resource poor farmers (Bovell- Benjamin, 2007) [8]. It also have a diverse range of positive attributes like high yield with limited inputs, short duration, high nutritional value and tolerance to various production stresses. These crops are said to be a native to Central America and are one of the oldest vegetables known to man (WHFoods, 2014) [48]. Asia as a whole accounts for about 78% of the world area under this crop and about 92% of the world production. India is one of the leading producers of this crop along with China, America, Brazil, Peru, Mexico and Thailand. India accounts for about 68% of the total production of South Asia followed by 27% in Bangladesh and about 5% in Sri Lanka. In India, Sweet potato is cultivated mainly in Orissa, Uttar Pradesh, West Bengal, Bihar, Karnataka, Tamil Nadu and Kerala (Mitra, 2012) [30].

Orange fleshed sweet potato

Orange fleshed sweet potato is now emerging as an important member of the tropical tuber crops. It is having a great possibility for being adopted as regular diet of the consumer food chain to tackle the problem of vitamin A deficiency. Apart from cheap source of energy, it is an excellent source of the β-carotene (Low et al., 2007) [23, 25] and is generally well accepted by young children (Wu et al., 2009 and Tumuhimbise et al., 2009) [67, 29, 54]. With the introduction of a large number of orange fleshed varieties having high β-carotene content ranging even up to 20-30mg per 100g (Padmaja et al., 2012) [35]. In addition to being rich in β-carotene, orange fleshed sweet potato contains significant amounts of protein, fat, carbohydrate, dietary fibre, zinc, potassium, sodium, manganese, calcium, magnesium, iron and vitamin C and some phytonutrients (Anita et al., 2006 and Mills et al., 2009) [2, 29]. 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 (USAID, 2015) [15]. It is also reported that one medium sized orange fleshed sweet potato can provide about twice the β-carotene needed for the recommended daily requirement of vitamin A. The roots are usually consumed after processing like boiling, baking or making fried chips (Vimla et al., 2011) [58]. Because of their nutritional qualities, sweet potatoes were selected as one of the food tested for long- term space travel (Wilson et al., 1998). Therefore, orange fleshed sweet potato is a staple food that can provide a supply of vitamin A and energy to people in both developing and resource-poor developing countries (Low et al., 2009 and Mitra, 2012) [26, 30].

It is the most suitting as biofortified crop to combat malnutrition in small and marginal farming community (Kidane, 2013) [19]. Orange fleshed sweet potato tubers are also a good source of energy, easy to cultivate, vegetatively propagated, and fairly drought resistant (Hagenimana et al., 2001) [15]. These characteristics make orange fleshed sweet potato an excellent food security crop. These are less labor intensive than most other staple crops and can be planted over a broad range of time without considerable yield loss (Woolfe, 1992) [56]. Thus, there is a great possibility of this subsistence crop for being adopted as regular diet of the consumer food chain to supplement as an alternative staple food source for the resource poor farmers in the era of extensive population growth and nutrition crisis (Low et al., 2007) [23, 25].

Bioavailability of β-carotene from orange fleshed sweet potato

Bioavailability of β-carotene depends on multiple factors. Dietary fat is necessary for absorption and conversion of β-carotene to retinol (Lemmens et al., 2014 and Mills et al., 2009) [22, 29]. The retention and bioaccessibility of β-carotene determine its bioavailability (Bechoff et al., 2011 and Transcoso – Reyen, 2016) [4, 52]. It has been documented that maceration and heat processing improve β-carotene bioaccessibility from orange-fleshed sweet potatoes, which is probably due to rupture of microstructure of plant tissue and subsequent release of nutrients from the complex food matrix (Van- Jaarsveld et al., 2006, Tumuhimbise et al., 2009, Thakkar et al., 2009 and Bengtsson et al., 2010) [57, 29, 54, 13, 29, 51, 5].

Health Benefits of Orange Flesh Sweet Potato

There are a surprising number of nutrients responsible for the health benefits of orange fleshed sweet potato tuber. Among these some are antioxidants, anti-inflammatory nutrients and blood sugar-regulating nutrients (WHfoods, 2014) [48]. Being rich in β-carotene, the orange fleshed sweet potato is gaining importance as the cheapest source of antioxidant having several physiological attributes like anti-oxidation, anti-cancer and may help in protection against liver injury and coronary heart disease (Choi et al., 2009, Mei et al., 2010 and Grace et al., 2015) [12, 28, 14].
Antioxidant Nutrients
Orange Fleshed Sweet Potato contains a wealth of orange-hued carotenoid pigments. In many countries, sweet potatoes are available on a virtual year-round basis and their ability to provide an antioxidant nutrient like beta-carotene makes them a standout antioxidant food (Han et al., 2007) [16]. Recent research shown that during the digestion process, while passing through digestive tract, phytonutrients present in these crops may be able to lower the free oxygen radicals heavy metals toxicity (Han et al., 2007 and Xie et al., 2010) [16, 68]. That risk reduction might be important not only for individuals at risk of digestive tract problems but for all persons wanting to reduce the potential risk caused by the presence of heavy metal residues in their diet. The Storage proteins i.e., sporamins present in sweet potato also have some important antioxidant properties (Ozaki et al., 2010) [33]. These storage proteins produced by sweet potato plants, whenever they are subjected to physical damage. Their ability to help the plants heal from this damage is significantly related to their role as antioxidants (Chang et al., 2010) [10]. Especially when sweet potato is being digested inside of our gastrointestinal tract, we may get some of these same antioxidant benefits (Filla et al., 2009) [15].

Anti-Inflammatory Nutrients
The colour-related pigments (carotenoids, anthocyanin etc.) present in sweet potato are equally valuable for their anti-inflammatory health benefits. In animal studies, activation of nuclear factor-kappa B (NF-kB), activation of inducible nitric oxide synthase (iNOS) and cyclooxygenase-2 (COX-2) and formation of malondialdehyde (MDA) have all been shown to get reduced by consumption of either sweet potato or its colour-containing extracts (Hwang et al., 2010) [17].

The colour-related sweet potato phytoneutrients also have their impact on fibrinogen (Ludvik et al., 2008) [27]. Balanced amounts of fibrinogen, thrombin and fibrin are a key part of the body's health and its ability to close off wounds and stop loss of blood. However, excess amounts of these clotting-related molecules may sometimes pose a health risk. In animal studies, excess fibrin in the central nervous system has been associated with increased demyelination process in neurons and can also trigger unwanted inflammation in nerve tissues (Zhang et al., 2009) [70]. In preliminary animal studies, intake of sweet potato coloured extracts has been shown in reduction of inflammation and also simultaneous reduction of fibrinogen levels (Wang et al., 2010 and Mei et al., 2010) [59, 68, 28].

Hypoglycaemic effect
These tubers have their ability to potentially improve blood sugar regulation in type 2 diabetes persons in spite of their medium glycemic index (Ozaki et al., 2010 and Bahado et al., 2006) [43, 3]. Recent research has also shown that sweet potatoes extracts can significantly increase the blood adiponectin levels in persons having type 2 diabetes (Ludvik et al., 2008) [127]. Adiponectin is a protein hormone produced by fat cells of body, and it serves as an important modifier of insulin metabolism. These tubers have high fiber, antioxidant nutrients like Vitamin A, Vitamin C, zinc and other micronutrients like potassium, magnesium, iron and Vitamin B, which help in diabetes management and prevention of other complications such as heart attacks and stroke( Han et al., 2007) [16].

Other Potential Health Benefits
One of the more challenging nutrient groups provided by sweet potato is the resin glycosides, called batatins (including batatin I and batatin II) (Yin et al., 2008) [69]. But, recently researchers discovered a related group of glycosides in sweet potato called batatosides (including batatodide III, batatoside IV, and batatoside V) (Philpott et al., 2009) [137]. In laboratory studies, most of these sweet potato glycosides have been shown to have antibacterial and antifungal properties (Noda and Horiuchi, 2008) [12]. But, to what extent these resin glycosides in sweet potatoes can provide a health benefit to human is not yet clear.

Food uses of orange fleshed sweet potato
Orange fleshed sweet potato can be termed as a “three in one” tuber, as it integrates the qualities of cereals (high starch), fruits (high content of vitamins, pectins, etc.) and vegetables (high content of vitamins, minerals, etc.). These tubers are extensively eaten after boiling, baking and roasting by Asian and South East Asian population. The beneficial effects of these ingredients have been appropriately put to use by converting the roots into a number of intermediary food products like jam, jelly, soft drinks, pickles, fried chips, bakery items sauce, candies, etc. (Singh et al., 2008, Padmaja et al., 2012 and Sindi et al., 2013) [45, 34, 49]. Orange fleshed Sweet potato has been processed into a dry cubes type food product. They are prepared after peeling, slicing into long pieces, soaking them in 2% (w/v) potassium metabisulphite solution and cooking in a 60° Brix syrup containing 0.8-1.0% citric acid. This is then dried and packed (Truong, 1987) [83]. Sweet potato contains water-soluble pectin, which enables its use in making jams and jellies (Truong, 1987) [53]. Picles have been also made from orange fleshed varieties in Bangladesh, Philippines and also in India (Padmaja and Premkumar 2002 and Tan et al. 2005) [34, 49]. Orange fleshed Sweet potato based composite flours have been used in many countries for making small baked goods like cakes, cookies, biscuits, buns, muffins, doughnuts etc. (Salma and Zaidah, 2005, Low and Van- Jaarsvald, 2008, Laurie et al., 2012 and Teferra et al., 2015) [41, 24, 20, 50]. French fry type products have been also prepared from sweet potato in Thailand (Reungmaneepaitoon et al. 2005) [39]. Ready to eat and Ready to cook breakfast food and snacks have also been made from orange fleshed sweet potato tubers (Lee, 2005) [21].

Curd is a popular food item for the Asians and is generally made from milk. Orange fleshed Sweet potato varieties were used to prepare curd having high nutritive value. The β-carotene rich variety yielded curd with a carotene content of 2.6 mg per 100g (Ray et al. 2005) [38]. The sensory evaluation of these curd also gave high scores for taste, aroma and texture (Panda and Ray, 2007) [36]. Orange fleshed Sweet potato tubers are dehydrated and converted into flour to increase the shelf life of stored tubers and also its further use in starch, paste, noodle and alcohol factories (Wiersma et al. 1989 and Chen, 2003) [53, 11]. Orange fleshed Sweet potato flour was also attempted as a replacer of flour and starch in making of candy (Samisiah et al., 2005) [42]. These crops flour can also be utilized to make gulab jamun by mixing it with refined wheat flour and milk powder (Padmaja and Premkumar, 2002) [34]. The high quality puree made from Orange fleshed Sweet potato is used directly as a baby food or used for mixing various food items like patties, flakes, reconstituted chips, etc. (Bouwkamp, 1985 and Woolfe, 1992) [7, 66]. Puree making also ensures round the year availability.
and better storage life. Restructured sweet potato sticks were made from cooked and mashed orange fleshed sweet potato using extrusion technology (Utomo et al. 2005) [56]. Non-alcoholic beverage has been also prepared from orange fleshed variety of sweet potato by mixing the cooked and mashed pulp of sweet potato with pulp of ripe mango or fruit juices from orange, lemon, pineapple etc. in India (Padmaja and Premkumar 2002) [34].

Conclusion

However, a large number of consumers are not aware about nutritional importance of this crop. It is possible only when low cost diverse technologies for value added products from orange fleshed sweet potato will be developed. Thus, there is a great possibility of this subsistence crop for being adopted as regular diet of the consumer food chain to supplement as an alternative nutritious food source for the resource poor farmers in the era of extensive population growth and nutrition crisis. In addition to the promotion of orange-fleshed sweet potato in household diets, the nutrition education regarding the function and importance of vitamin A in the diet could improve the vitamin A status to combating night blindness, the major public health concern in unprivileged areas.

References

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