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Review

History Development and Impact of Orange Fleshed Sweet Potato Varieties in Nigeria Since 2012 - A Review

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The objective of the study was to review the history and development in the breeding of orange fleshed Sweet potato (OFSP) varieties in Umudike, Abia State in the Southeastern Nigeria. This was made in order to evaluate the impact of the orange fleshed sweet potato varieties since its official release in the year 2012 and 2013. It was observed that OFSP had made tremendous contributions in the field of agronomy, food science, commerce, health and in the economy of the country, Nigeria. The production, marketing and utilization of the OFSP have expanded to almost all the ecological zones within the past seven years starting from 2012 to 2019. For instance, over 400,000 hectares of lands are under OFSP cultivation. Yields of OFSP storage roots have increased from farmers' pre-research era of about 3 tonnes to 20-30 tonnes per hectare. The total annual production of OFSP in Cross River, Ebonyi, Nasarawa, Benue and Enugu States of Nigeria has increased from 47,580 to 95,596 tonnes in the years 2014 to 2018. Similarly, its consumption as food and in processed forms has increased tremendously in many States within the same period. The utilization of the roots as feed has increased from 340 to 11,520 tonnes while domestic sales increased from 33,550 to 90,970 tonnes. Traditionally, OFSP are used as boiled storage roots and eaten with stew, eaten raw or sliced and eaten as root salad, or grind

and drink as juice. In addition, OFSP contributes significant amount of vitamins A, C, K and several B, vitamins. The leaves of OFSP varieties have good micronutrient contents such as iron and adequate protein (4%) for use as food and animal feed. OFSP is a good source of dietary fibre of about 2.5 to 3.3g/100gm and is classified as a low glycemic index food and therefore does not increase the risk of diabetics. Women in particular are making significant profit from selling fresh roots of orange fleshed sweet potato in local markets, and higher female income translates into better household nutrition and welfare. Bulk of the research activity now in sweet potato is toward OFSP. Thousands of research publications and research findings are now based on OFSP. OFSP storage roots are now being beckoned outside the country and is now included as article of international commerce. The historical record of the development of OFSP in Nigeria indicated that Sweet potato Research Programme of National Root Crops Research Institute Umudike, Umuahia Abia State located in Southeastern Nigeria is not resting or sleeping in carrying out its national mandate. The historical record of the development of OFSP also showed that, there is readily available and adequate literature on OFSP in Nigeria. The information could help the local authorities and policy makers take good decisions that would move the economy of the country forward.

Keywords: Orange fleshed sweet potato, Official release, Impact, Vitamin A and welfare.

INTRODUCTION

Agriculture supports more than 80% of the million households in Nigeria in terms of food, income and employment. Malnutrition leads to stunting of growth in children which is spatially distributed and highest among poor households in Nigeria. The cost of malnutrition in Nigeria is 12% of the Nation's Gross Domestic Product which is equivalent to 2.4 billion US dollars according to FAO (2013) and Latruffe (2010). In the above mentioned conditions, Orange fleshed sweet potato (OFSP) plays a significant role in combating food shortages and malnutrition. At the same time has the potential to maintain human health by mitigating diseases and generating income to improve the livelihood of the people. As a result of the importance of OFSP as food in Nigeria, the National Root Crops Research Institute (NRCRI) Umudike in Abia State, Nigeria has the national mandate to carry out research into the genetic improvement, production, processing, utilization, marketing and storage of all root and tuber crops of economic importance (including sweet potato) in Nigeria.

The National Root Crops Research Institute (NRCRI) Umudike is serious in pursuing its mandate based on the fact that Population and urbanization increases in Nigeria are increasing at an alarming rate. The same thing is seen in most neigbouring countries in Africa. OFSP smallholder farmers in Nigeria need support to be able to increase production of food crops in a sustainable way, in order to feed their families, provide food for wider population and the rapidly expanding urban centers, and export to nearby countries. Already OFSP has the potential for industrial uses such as providing feed and fodder for livestock and starch for markets (Panta et al., 2007). In addition, OFSP serves as food security crop for the masses.

OFSP is also an important staple crop in many regions of Sub-Saharan Africa (Onwueme and Sinha, 1991). It is grown mainly for the enlarged storage

roots, which are usually eaten fresh, boiled, fried or roasted and the leaves may also be used as forage for livestock, or eaten as a vegetable (Loebenstein et al., 2003; Agrodok, 2013). Loebenstein et al., (2003) noted that OFSP comes in various skin colours ranging from light cream, yellow, orange, and deep purple. The flesh colour ranges from light orange to deep orange. The National Root Crops Research Institute has made tremendous effort in repositioning OFSP crop amongst other commodity crops in Nigeria. The research activities of this Institute have resulted in Nigeria being ranked as the 4th largest producer of Sweet potato in the world and the 3rd largest producer in Africa with a total production figure of 4,013,786 metric tons in 2017 representing 3.6 % of the world production figure for 2017 (FAOSTAT, 2017).

In other to increase the genetic base of the crop in Nigeria, the NRCRI has developed and released four new varieties of Sweet potato. These varieties are given official catalogued code named as UMUSPO/1, UMUSP/2, UMUSPO/3 and UMUSPO/4 released in 2018 christened Solo-gold. Three (UMUSPO/1, UMUSPO/3 UMUSPO/4) out of the four varieties released by the Institute are orange-fleshed sweet potatoes (OFSP). These varieties are high-yielding and resistant to major sweet potato pests and diseases. OFSP is rich in beta-carotene which is converted into vitamin A in the human body (SASHA, 2011, Low et al., 2017). Vitamin A is an essential nutrient that prevents blindness in children and build up immunity in pregnant women (IFPRI, 2009). Vitamin A deficiency among people in most sub-Saharan African countries results in increased risks of severe infections and even death from common diseases such as diarrhea and measles (WHO, 2011). Promotion of OFSP has proven to be an effective food-based approach to increase vitamin A in-take and serum retinol concentrations in young children in rural Mozambique (Low et al., 2017). OFSP is a vegetative propagated crop, grown and harvested in a 4-5 month cropping cycle, starting each cropping cycle by planting cuttings or seed vines. Of all the varied flesh storage root colour (white, yellow, cream, brown, purple, pink) of sweet potato varieties existing, the orange fleshed root and Purple fleshed sweet potato varieties are so little known in Nigeria and are so rich in vitamins. However, the orange and purple fleshed sweet potato is extremely rich in bioavailable beta-carotene, which the body converts into vitamin A. According to Sweet potato knowledge (2012), one small root (100 - 125 grams) of most OFSP varieties can supply the recommended daily dose of vitamin A for children under five years of age. In addition, OFSP contributes significant amount of vitamins C, E, K and several B vitamins. The leaves also have good micronutrient contents and adequate protein (4%) for use as food and animal feed. OFSP is also a good source of dietary fiber (2.5 - 3.3g/100gm), and is classified as a low *glycemic* index food (Sweet potato knowledge, 2012). Generally, OFSP can be produced at relatively lower cost than yam and cassava. The OFSP enlarged roots can be processed into different bakery products and the orange colour attracts consumers. Women in particular can make significant profit from selling OFSP fresh roots and products, and higher female income translates into better household nutrition and welfare. Population increase and high rate of urbanization have given rise to the need for inexpensive but healthy foods for the urban poor and created concurrent demand for fast food outlets and healthier foods by a growing middle class. The nutrition advantage of OFSP offers a unique opportunity to promote increased marketing and processing of OFSP, which will boost demand and ultimately pushes the increase in income generation (Sorense, 2009). OFSP can substitute for potato in making chips and crisps and serve as a partial substitute (20 - 50%) for wheat flour in bakery products. OFSP products have a golden colour that make it easy for marketing campaigns thus

increasing demand. All classes of farmers can grow and invest in fresh root products and marketing of OFSP.

In general, OFSP have been consumed as carbohydrate food by man in various ways. Many parts of the OFSP plant, such as the leaves, roots and vines, are edible. The OFSP storage fresh roots can be boiled, steamed, baked, and fried into chips and eaten, pounded or mixed with yam as porridge and or eaten with vegetable soup, roasted and eaten with oil or sauce, made into porridge, used in preparing “kunnu” drink. OFSP roots could be used as sweetener, eaten boiled with rice, processed into kunuzaki which is oiled and eaten with groundnut cake, Fresh OFSP leaves are used in making vegetable soup and served with pounded yam, “Eba” or “Amala”.

In Japan, OFSP storage fresh roots are canned or dried and made into flour, or noodles. OFSP roots are often used in sweet dishes, such as pies, puddings, biscuits, cakes, and desserts or processed into products such as chips, OFSP “Sparri” (toasted “sparri” granules) soaked in water and eaten with groundnut as a snack or put in boiled water and served with soup, OFSP cake eaten as snacks or main dish to entertain visitors, puff-puff, buns, bread, crisps, chin-chin served as snacks, ketchup (chopped boiled OFSP storage roots mixed with tomato, sugar, onions, vinegar, salt, water) served with bread for breakfast, OFSP chips (deep fried sun-dried chips) eaten as snacks, OFSP Jam served with bread for breakfast (Odebode, 2004). The roots can be pre-sprout and used in making vegetable salad or drink-juice.

The OFSP is a nutritionally rich crop. It contains antioxidants, the major antioxidants in the sweet potato is phenolic acids, anthocyanins and carotenoids, especially beta-carotenes. Beta-carotene and anthocyanins exist in high quality OFSP roots with a range of flesh and skin colours. The crop contains vitamins such as (B1, B2, B3, B5, B6, B9, C and E), minerals (iron, calcium, magnesium, phosphorus, potassium and zinc), dietary fiber, protein and carbohydrates (Suda et al., 1999). The crop is also known to contain high amount of soluble sugar such as cellulose, pectin, and hemicellulose. SASHA (2011) reported that the roots and leaves of OFSP contain appreciable amount of protein (about 5% of the dry matter), Lipid (approximately 1.2-2.7% of the total fresh weight), amylases and phytochemicals such as ascorbic acid. According to WHO (2011) reports, every year an estimated 861,000 Nigerian children die before the age of five, over a third of these deaths are attributed to malnutrition. Forty- one percent of children under five years are stunted. Infant and young child feeding is characterized by low rates of exclusive breastfeeding, poorly timed introduction of complementary foods and a high prevalence of deficiency of essential micronutrients (vitamin A, Zinc and Iron). Almost 30% of pre-school aged children in Nigeria are deficient in vitamin A, a micronutrient that helps young children grow and develop normally and stay healthy. Women of childbearing age, food insecure and HIV/AIDS affected households are also at high risk of vitamin A deficiency (VAD) (Walter et al, 1992). Vitamin A deficiency (VAD) contributes to significantly high rates of blindness, diseases and premature deaths in Sub-Saharan Africa (SSA). Young children and pregnant or lactating women are particularly at risk of VAD (IFPRI, 2009). As a result of the nutritious food benefit of OFSP, the challenge is to introduce the beta-carotene rich varieties and promote their production, uptake and consumption. The climate change which is characterized by limited rainfall and changes in rainfall patterns affecting cropping systems in Nigeria could hinder sustainable storage of fresh roots and seed vine production of OFSP. However, OFSP is among the most resilient crops to abiotic stresses, and is considered a key crop for mitigation of climate change and weather variability as Sorense (2009) reported.

Recently, there has been an increasing awareness on the part of farmers in Nigeria on the potentials of

OFSP as a global nutritious food security crop and this awareness has resulted in a gradual steady increase in the area of OFSP crop under cultivation in Nigeria (Ammirato and Yamada, 2010). But notwithstanding this positive development, OFSP production in Nigeria is still bedeviled with numerous challenges such as low yield. The average yield of the crop is still within a very low range of 3.0 t/ha compared with average yield values of 15 – 30 t/ha obtainable from other sweet potato-producing nations of the world like China (Onwueme and Sinha, 1991, Odebode, 2004). Among the factors implicated for the low yield trend of the crop in Nigeria, is the annual recycling of vines heavily-loaded with pests and diseases (such as virus disease) (Islam et al., 2002; Jeude, 2004) and scarcity of quality seed vine materials (Sorense, 2009) have been identified as the greatest challenge. Other factors such as lack of well-defined seed system, low soil fertility, poor agronomic management practices and use of low-yielding varieties and landraces (Kou, 1991, Kreuze and Fuentes, 2008) also play a role in reducing the yield of the crop in Nigeria.

Use of quality seed vines (cuttings) in any crop production is a very critical factor influencing yield of that crop. NRCRI made tremendous efforts in producing quality pre-basic seed planting materials and making these materials available to farmers under the Sweet potato Action Security and Health in Africa (SASHA) Project. This project aimed at ensuring that quality seed vines of the OFSP varieties released by the Institute are produced under disease-free environments using the net tunnel and screen house and are sold to farmers to enable them have a stock of clean materials for their OFSP root production on sustainable basis. This project was carried out on a pilot scale using 3 states in Nigeria (Abia, Nasarawa and Osun). The result of this project enabled many more OFSP-producing states with funding limitation access to clean planting material instead of using and exchanging poor quality, disease-infected seed vine materials for commercial storage root production (Henderson et al., 1984; Dangler et al., 1994). Using a community-based approach in the production and distribution of quality OFSP seed vine materials was of immense help in strengthening the formal seed system in OFSP value chain and in assisting farmers see the need to adopt OFSP and expand on its production not only for improving their income, health and nutritional status but also for export. Today sweet potato research programme of NRCRI, Umudike is rated by CIP as one of the programmes that has active sweet potato breeding programme in Africa.

The objective of this work is to review the historical development in the breeding of orange fleshed Sweet potato (OFSP) in Umudike, Abia State, Southeastern Nigeria and the impact of the OFSP varieties since its official release in the year 2012.

HISTORICAL DEVELOPMENT IN THE BREEDING OF ORANGE FLESHED SWEETPOTATO IN UMUDIKE, NIGERIA

Sweet potato Research programme is solidly behind the cassava research programme among the Seven leading Root and Tuber research programmes of National Root Crops Research Institute, Umudike, Nigeria. The Sweet potato Programme which came into existence in 1975, has contributed to the sweet potato industry in Nigeria in two ways: one through breeding of almost all the commercially grown sweet potato cultivars, and two by a scheme for making available virus-tested propagation material for commercial sweet potato root production. From that year (1975), the Sweet potato Research Programme has increased the sweet potato production capacity of the resource-poor agriculture sector. Breeding was aimed at improving the yield and quality as well as storability and early maturity of local varieties. This period was also characterised by collection and

evaluation of landraces and elite genotypes from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Traits screened for included, fresh root yield, pests such as*, Cylas spp* resistance, dry matter content, starch content, flour content and reducing sugars. IITA was responsible for the development of new segregating populations for National Agricultural Research Institutes of various countries in Africa. Sweet potato breeding during the late 1970s was carried out by IITA doing the crossing and distributing the hybrid progenies to National Programmes. However, National Root Crops Research Institute (NRCRI) Umudike involved in field evaluation of sweet potato lines for yield and other traits. Throughout this period, no variety was officially registered for release to Nigeria farmers.

By 1989, IITA lost the global mandate on sweet potato research to International Centre for Potato (CIP), Peru in Lima South America. This global centre has the mandate on sweet potato research. IITA then turn over 400 sweet potato accession in their germplasm to NRCRI Umudike that had the National mandate on sweet potato research. With this development, Umudike started its own breeding with its own breeder Dr Mba. Dr. Mba left the Institute by early 1991. The Breeding activities in Umudike underwent into a state of inactivity till the year 2002 when an exuberate young man, fresh from school was posted to Sweet potato Research Programme in the person of Afuape Solomon in the days when Dr Nwauzo was the coordinator of Sweet potato Research Programme.

The Breeding Programme progressed more from evaluating clonal landraces to testing exotic materials for adaptation. Afuape and Nwauzo made tremendous effort to attract projects from abroad that will sponsor the breeding and release of exotic materials. The struggle continued until the retirement of Dr Nwauzo. In 2008/2009 Afuape concluded his masters' degree in Plant breeding and Genetics from Michael Okpara University of Agriculture, Umudike Umuahia, Abia State, Nigeria. An opportunity came for him to travel to Donald Danfort Centre of Plant Science in the USA to learn new tools in biotechnology. This was with a view to advance sweet potato breeding using biotechnological tools. He was asked not to leave until a breeder should be posted to the programme. It was at this time of need that Nwankwo Innocent Ifeanyi Maxwell concluded his second masters in Plant Breeding and Genetics at Michael Okpara University of Agriculture, Umudike Abia State, Nigeria. (his first masters was in the field of Agricultural Economics at Abia State University, Uturu in 2004). Although Nwankwo who was working under Dr Nwachukwu, in yam breeding then as a higher Agricultural Superintendent, did not know what was happening behind the scene, he applied for conversion as a Research Officer, and was converted within one week during the tenure of the late Executive Director Ken I. Nwosu and was immediately posted to Sweet potato Research Programme as a breeder. This gave Afuape the opportunity to travel abroad as he planned.

Nwankwo assumed office as sweet potato breeder. Backed up by the Executive Director K.I. Nwosu and encouragement from Prof. Egesi, C.N, Dr Nwankwo went down to work. He initiated a research project for the genetic transformation of sweet potato varieties through genetic recombination in order to introduce resistance genes to sweet potato genotypes against sweet potato feathery mottle virus (SPFMV). SPFMV is a killer disease of sweet potato that may reduce yield up to 100%. Introgression of genes for higher storage root and foliage yield plus pushing the dry matter to higher percentage. The development of orange fleshed sweet potato genotypes was given a priority during the years 2009 to 2011. In 2010 alone, over 700 different genotypes of OFSP, six different genotypes of Purple fleshed, over 200 genotypes of Yellow fleshed and 127 white and creamed fleshed genotypes had been developed through genetic recombination of sweet potato parents.

The Executive Director Dr Nwosu often asked Nwankwo when he was going to release sweet potato variety and Prof. Egesi, was under pressure from people who had been asking why sweet potato has not been released by the Institute. As for Nwankwo his experience on yam breeding activity came to the fore. In 2009 Nwankwo was sent to International Institute of Tropical Agriculture – Ibadan by Dr Nwachukwu E.C., to learn how to pollinate yam by hand and was the first to pollinate yam by hand at the National Root Crops Research Institute, Umudike. At the yam breeding section, yellow yam and white yams were being evaluated separately. In fact, all yam species were evaluated separately. At the Sweet potato Research Programme, Nwankwo decided to separate all the varieties and evaluated them separately. By then, there were only nine exotic materials that were light orange plus centennial (an American variety which is deep orange but does produce pencil-like roots). These were constituted in the hybridization block for inter-mating and controlled crosses.

Nwankwo was also the first person to use hand in pollinating sweet potato at the NRCRI Umudike. He produced a number of seeds for evaluation. In order to increase the number of OFSP varieties in his collection, he and some sweet potato field staff notable Erigbo Godfrey will be opening the soil using Machetes and knives to cut at the enlarged roots of the sweet potato seedlings to see if any were orange, then tagged it for selection. That was how NRSP/022 (UMUSPO/1) which is now the famous King J was selected from the sweet potato seedling nursery established with seeds generated from inter-mating of parents. King J was an open pollinated progeny from the parent CIP 199004.2. The OFSP genotypes were evaluated across the agro-ecological zones. Dr Jude Njoku conducted the on-farm trials across the Northern part of the country, Nwankwo I.I.M conducted the on-farm trials in the Southeastern and Western and the South-South humid agro-ecology of the country. Nwankwo I.I.M was the breeder and the coordinator of the trials under Nationally Coordinated Crop Release Project (NCRP) sponsored by AGRA. (Alliance for a Green Revolution in Africa) which is a partnership-driven institution that is African-led and farmer-centered founded in 2006, with headquarters in Nairobi Kenya. Many other scientists engaged in many other essential functions necessary for the release of the OFSP such as sowing and participating in transplanting and plant sampling, monitoring and data collection on OFSP trials both in greenhouse and field conditions. Some other Scientists did a collaborative participatory harvests trial of OFSP varietal selection of OFSP genotypes across the country's various agro-ecologies. Pollination, Seed collection and cleaning plus seedling evaluation for more development of OFSP varieties were continuously being carried out. Other field workers in the programme also participated in field trial maintenance including pest scouting, weed control and trellising in the hybridization block. They also did other secondary responsibilities such as assisted with field layout, and transplanting of seedlings to field trials and maintenance of general ground areas. Omodamiro carried out all the Proximate and functional properties of the OFSP while Ivory Chimaobi did the calibration of the carotenoid content of the OFSP genotypes.

Official release of orange fleshed sweet potato in Nigeria

The first released of OFSP varieties in Nigeria was in the year 2012. Before then, OFSP is so little known in Nigeria up till that year. The only known registered sweet potato varieties were developed by IITA, Ibadan developed by Dr Hahn of the IITA and released in 1992 but registered by NRCRI Umudike in 2001. The three varieties registered that very year were all white fleshed varieties (NACGRAB, 2014).

The OFSP genotypes released in Nigeria in 2012 by the Sweet potato breeding unit of NRCRI, Umudike OFSP varieties selected from exotic varieties for cross breeding by Dr Nwankwo Innocent Ifeanyi Maxwell of the NRCRI, Umudike Umuahia in Abia State Nigeria which led to the official release of these varieties in 2012. The first OFSP released in Nigeria is known as UMUSPO/1 (Umudike Sweet potato orange one) fondly called King J. The name was given to it by Dr Jan Low at the 11th Sweet potato Breeders' Annual Meeting at Kigali, Rwanda, in April 22-26, 2013 being organized by the International Potato Center (CIP) and the Rwanda Agriculture Board (RAB) as part of the Sweet potato Action for Security and Health in Africa (SASHA) Rwanda. It was named in honour of the then President of Nigeria- Goodluck Ebele Jonathan. King J yields very highly with potential yield of 63.63t/ha. Semi – erect plant with thick vine and very vigorous growth of dark green leaves. It has wide Adaptation both in rainforest up to the northern Guinea Savannah. It matures in about 120 days after planting. One of its outstanding characteristics is that it is resistant to Sweet potato virus disease (SPVD), and tolerant to *Cylas* spp weevil. Light orange with dry matter content of 39.0%. The variety is not only like by animals, it is consumed by both adult and children. Road Side fast food processors like it much simply because it does not consume much of their frying oil.

Nutrient content includes: Total carotene: 7.12 µg/g fresh weight; Protein (3.94%); Starch (19%); Dry matter (39%); Flour yield (32%).

Another variety released that year was UMUSPW/2. This was a white variety but since the emphasis was on Orange fleshed, it seems as if this variety was kept at the background. UMUSPO/3 was a deep orange fleshed variety. Unfortunately, it failed to be released that year simple because as one of the members of National Varietal Release Committee pointed out, that the yield was low in the Developing Institute (NRCRI, Umudike). This particular statement sparked out a lot of controversy and argument among the committee members. The members argued that yield alone is not a criterion for releasing a variety.

Other attributes must come to play before a variety must be released. Besides, it has a distinctive characteristic of being deep orange fleshed with purple creeping vine, heart shape leaf with yield potential of 31.4/ha and matures in 3 - 4 months after planting, tolerant to Cylas spp weevil and tolerant to Sweet potato virus disease (SPVD). This variety is widely adapted more to the low SPVD pressure ecologies of Southern Guinea to the Northern Sudan savannahs and yield very highly. The committee requested for additional data from the developing Institute indicating that it yields highly to enable its release the following year. The experiment conducted by Dr Jude Njoku on "Adaptation Trial of Orange Fleshed Cultivars of Sweet potato in Rainforest and Guinea Savannah of Nigeria by Njoku, and Amadi, in 2011 at the NRCRI, Umudike. Umuahia was presented the following year 2013 where it had yield of 9.0t/ha at Umudike and 40.9t/ha at Nasarawa State. Immediately after the presentation of this result, the National Varietal Release Committee accepted the variety without a question. They said "this variety was presented last year 2012 and we all fell in love with the variety" (Appendix 1).

For the first time all the varietal release committee members ate UMUSPO/3 as if it were a carrot. Before the conclusion of the meeting, every one of them were rushing and scampering for the vine cutting for private planting. At Umudike the developing Institute, there was jubilation that the beloved variety was eventually released.

The committee wanted to be sure that the colour was not genetically modified. The fact was that orange fleshed sweet potato developed at Umudike was natural. Its Pedigree was BP-SP-2 (CIP Office in

Nairobi, Kenya). It was not genetically modified neither was any genes insertion from carrot. The colour of the variety is natural. The root dry matter is 28.70%, Starch of fresh roots is 13.16 %, Flour yield is 21.15, Proximate compositions: Crude fibre is 2.0%, Fat content is 1.7%, Ash content is1.5%, Crude protein is 5.6%, Total carotene content is 20.83ug /100g, FW. Due to its appetizing egg yolk deep orange flesh colour which indicated high vitamin A content, this variety was fondly named "Mother's delight" by Dr Jude Njoku in the year 2013. In 2018, UMUSPO/4 (Sologold) was released. It has a potential yield of 25.61t/ha. The young leaves are purplish, the dry matter content is higher than UMUSPO/3 and resistant to Sweet potato virus disease complex in virus hotspot areas. As at 2019, Dr Nwankwo has over 700 bred OFSP hybrid genotypes in his collections and six purple fleshed sweet potato hybrid genotypes and other varieties of sweet potato genotypes at different stages of evaluation for possible release to the Nigerian communities.

Multiplication and Distribution of the Orange Fleshed Sweet Potato Varieties in Nigeria

Immediately the orange fleshed varieties were released in 2012 and 2013, number of activities were unleashed for the multiplication and distribution of these two pioneer varieties. A project known as RAC (Reaching Agents of Change) under the Directorship of Dr Jude Njoku was to multiply and distribute the seed vine of these varieties for sweet potato root production. Decentralize Vine Multipliers (DVM) were established in major sweet potato growing States in Nigeria notably Ebony State, Nassarawa State and Benue State.In total ten trained DVMs were established across the country.These were to multiply the seed vines and sent especially to six States in the Western part of the country which were taken as pilot States.

The potential of orange-fleshed genotypes in alleviating vitamin A deficiency

A pilot project was conducted in Osun State Nigeria in partnership with the NRCRI to test the food-based approach for alleviation of vitamin A deficiency. A high percentage of preschool children in the community had low blood serum retinol levels. The project involved training agricultural extension agents to monitor the production practices of vitamin A rich OFSP. Then formal cultivated plots of these OFSP rich in vitamin A was planted as a vegetable and were established to demonstrate to mothers how to establish their own OFSP farms. The agricultural extension agents were available to monitor and to give advice to these farmers. To monitor the production of the OFSP rich vitamin A crops, an Agricultural Extension Agent visited the farms at intervals to assess the yields of the OFSP and to advise trainers, and to identify problems and provide possible solutions. Also, education in the preparation of food supplements with OFSP roots and leaves were under taken under the supervision of the NRCRI field staff. Seed cuttings of the OFSP cultivars UMUSPO/I and UMUSPO/3 were established in the prepared land in the communities in Osun State. These two cultivars were chosen only because there was sufficient planting material available. The cultivars have very high beta-carotene content, and were excellent cultivars to use for this purpose. Mothers of pre-school children obtained seed cuttings of the orange- fleshed cultivars from the NRCRI Umudike to plant in their homes. UMUSPO/3 was judged by members of the community to be softer, tastier and they prefer to grow and consume this cultivar although it was claimed to consume much of their frying oil. The pilot programme concluded that OFSP can play an important role in a food-based approach in alleviating vitamin A deficiency in the community in particular and in the country in general and there is a good possibility of

OFSP varieties being adopted in place of the white/cream- fleshed genotypes if consumers are given nutrition education/awareness.

IMPACT OF ORANGE FLESHED SWEETPOTATO VARIETIES IN NIGERIA

Looking back starting from 2012 to 2019, what had been the contribution of OFSP varieties to the country's economy and health status of the people of Nigeria? OFSP is widely grown in Nigeria because of its ease to grow, it is resilient short maturing between 3 to 4 months, it has the ability to grow under marginal conditions. OFSP has flexible planting and harvest time. It is food well cherished by man and animals. These numerous attributes led to its driving cultivation and industrial value addition expansion throughout the country. OFSP released has made tremendous impact in the lives of the people. There are very few states in Nigeria that do not consume sweet potato as staple. However, there are major sweet potato producing and consuming states in Nigeria like Ebonyi State, Benue State, Nasarawa State, Abia State, Oyo State, Lagos State, Cross River State, Osun State, Enugu State, Kaduna State, Plateau State and Kwara State, and even the Federal Capital Territory Abuja (Figure 1). The released OFSP first reached these States before spreading to other neighboring States.

Since the official release of the OFSP in the country Nigeria in 2012 and 2013, the production, marketing and utilization of the OFSP have expanded to almost all the ecological zones within the past seven years starting from 2012 to 2019. For instance, over 400,000 hectares of lands are under OFSP cultivation. Yields of OFSP storage roots have increased from farmers' pre-research era of about 3 tonnes per hectare to 20-30 tonnes per hectare. The total annual production of OFSP in Cross River, Ebonyi, Nasarawa, Benue and Enugu States of Nigeria increased from 47,580 to 95,596 tonnes from the years 2014 to 2018. Similarly, its consumption as food and in processed forms increased tremendously in many States within the same periods. The utilization of the roots as feed increased from 340 to 11,520 tonnes while domestic sales increased from 33,550 to 90,970 tonnes. Traditionally, OFSP are used as boiled storage roots and eaten with stew, eaten raw or sliced and eaten as root salad, or grind and drink as juice. OFSP is also dried and milled for sweetening of gruel ('*ogi*') porridge, sliced into chips, dried and boiled with beans or vegetables, sliced into chips and fried in vegetable oil, in addition to processing into flour for sweetening '*kunu*' or pap. OFSP root are boiled, sliced, sun-dried and used later as snacks, processed into flour for making buns, chin-chin, doughnut, noodles, alcoholic beverages, protein-enriched pulp and canned foods. OFSP is making a positive wave in the country. National Root Crops Research Institute, Umudike, the originating Institute of OFSP in Nigeria has a Kiosk designated for the selling of OFSP processed products within the Institute.

OFSP like other Sweet potatoes can be grown and harvested within four months than other root and tuber crops such as cassava, yam, cocoyam and ginger. Enlarged roots of OFSP harvested in three months could be used for making vegetable Salad. Specifically, OFSP can be grown two to three times in a year with supplementary irrigation. It requires low farm inputs, soil fertility and is highly adaptable to relatively marginal soils and erratic rainfall. OFSP has high productivity per unit area of land and labour requirement is minimal and guarantees some yield even under the most adverse conditions. However, use of fertilizer during the storage root production is a choice. Some say the taste is better without fertilizer, Others say the yield is better when you use fertilizer.

OFSP does not have the problem of anti-nutritional factors such as cyanides and oxalates that exist in

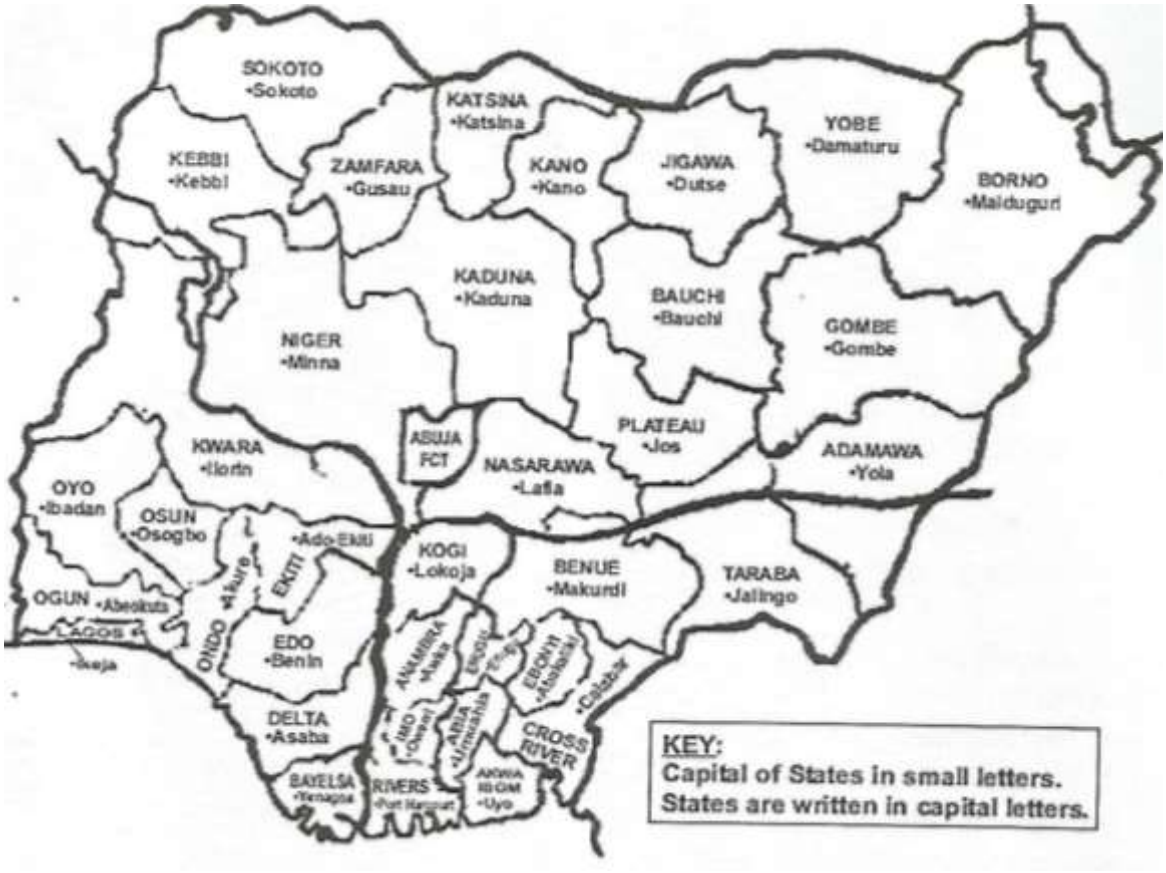

Figure 1. Map showing locations of sweet potato producing States of Nigeria.

Source: Ugo, (2000).

cassava and cocoyam respectively. Its high yield potentials and short life cycle of less than 20 weeks make crops like yam (*Dioscorea* spp) and cassava (*Manihot esculenta*) relatively Lilliput/ poor competitors for general industrial starch.

Impact of OFSP for Health Improvement: OFSP is a cost-effective nutritious crop that improves health. For example, Helen Keller International reported that 4.8 million children in Sub-Sahara Africa die each year before the age of five, and that one third of these deaths are attributed to under nutrition. They further reported that an estimated 44% of pre-school aged children in Africa and Nigeria inclusive are deficient in vitamin A, a micronutrient that helps young children grow normally and stay healthy. Women of

childbearing age, pregnant and lactating mothers are food insecure and HIV/AIDS affected households are also at high risk of vitamin A deficiency. OFSP could be used to combat the micronutrients and vitamin A deficiency in food products (Faber and Benadè, 2002). This is because OFSP is extremely rich in bioavailable beta-carotene, which the body converts into vitamin A (retinol) at a ratio of 12 to 1. Just one small root of 100 to 125 gm of most OFSP varieties supplies the daily recommended allowance of vitamin A for children under 5 years of age. Even at low yields of 6t/ha, about 500 square meters can generate an adequate annual supply of vitamin A for a family of five. That is why OFSP is referred to as vitamin A power house. In addition, OFSP contributes significant amount of vitamins C, K and several B vitamins. The leaves of OFSP varieties have good micronutrient contents such as iron and adequate protein (4%) for use as food and animal feed. OFSP is a good source of dietary fibre of about 2.5 to 3.3g/100gm and is classified as a low glycemic index food and therefore does not increase the risk of diabetics (Sweet potatoes knowledge, 2012). Sweet potatoes is a vegetative propagated crop grown in a 4-5 months cropping cycle, starting each cropping cycle by planting the seed cuttings. Generally, sweet potatoes can be produced at relatively lower cost than yam and cassava (Nwankwo and Bassey, 2013). The OFSP roots can be processed into different bakery products and the orange colour attracts consumers.

The Impact of OFSP on Women Empowerment: OFSP varieties are grown mainly by women. Women cultivate, sold and process OFSP in small quantities and as producers of OFSP and home managers, women play a very important key role in decision making about child feeding and the household nutrition. OFSP has relatively low cost of production and high productivity of root yield per unit area of production, as a result woman grow many varieties of OFSP, the surplus of the roots are sold to the market or processed into some other food products for the household or sold for additional income. Therefore, significant profits are made by women by these sales and which translate into better nutrition, higher income and better welfare. Women in particular are making significant profit from selling fresh roots of OFSP in local markets and higher female income translates into better household nutrition and welfare. Population increase and high rate of urbanization have given rise to the need for inexpensive but healthy foods for the urban poor and created concurrent demand for fast food outlets and healthier foods by a growing middle class. The nutrition advantage of OFSP offers a unique opportunity to promote increased marketing and processing of OFSP which will boost demand and ultimately produces incomes ((Nwankwo and Bassey, 2013). OFSP can substitute for potato in making chips and crisps and serve as a partial substitute (20 - 50%) for wheat flour in bakery products. OFSP products have a golden colour that make it easier for marketing campaigns thus increasing demand. All classes of farmers can grow and invest in fresh root products and marketing of OFSP.

Impact of OFSP on Income Generating Opportunities: In many urban cities across the country fast food outlets using inexpensive OFSP products are springing up. OFSP roots and products are healthier foods required by urban dwellers. The nutritional advantage of OFSP offers the opportunity to promote increased marketing and processing of OFSP. This in turn boosts the demand and increase the income of OFSP producers.

Impact of OFSP on Animal Nutrition: The sliced flesh roots could be dried and ground into flour or as chips for animal feeds. The leaves could be used as fodder for livestock. The leaves of OFSP could be dried and mix with poultry feeds and fed to laying

hens to increase the vitamin A contents of eggs. The root of this variety contains moderate amount of micro-nutrients such iron and zinc as well as beta-carotene more than the white varieties.

Impact of OFSP in Research Activity: The release OFSP in the country since 2012 has stimulated myriad of interest among various Scientists in different disciplines leading to dissemination of OFSP based technologies to end users. Many students are now working on OFSP in diverse disciples such as biotechnology, post-harvest, agricultural economics, agronomy, extension, crop production, breeding, crop protection, livestock, nutrition, health, soil conservation and management, farming systems. Bulk of the research activity now in sweet potatoes is toward OFSP. Thousands of research publications and research findings are now based on OFSP. Agribusiness students and others are now working on how many tones of OFSP foliage should be sold to livestock farmers per week, how many tones of seed vines (planting material) should be sold to storage root producers for planting one hectare of land and or how many tones of storage roots do baby food factory industries required as raw material that will last for the factory for one week.

CONCLUSION AND RECOMMENDATIONS

Active research and breeding activities over the years when NRCRI, Umudike inherited 400 accessions from IITA germplasm had led to a tremendous improvement on the cultivation and increase in the genetic base of the sweet potato crop. This has immensely contributed to the food economy of the nation. The history of sweet potato from 1975 till date is an indication that sweet potato research programme is not sleeping at all. Since the release of OFSP in 2012 in Nigeria, OFSP has made tremendous contributions in the in the field of agronomy, food science, health, commerce, research and economy of the country, Nigeria. OFSP has given employment to lots of people both to farmers, industrialists, roadside marketers and researchers. The production, marketing and utilization of the OFSP have expanded to almost all the ecological zones within the past seven years starting from 2012 to 2019. Our hope and recommendation is that other varieties of sweet potato should continue to be produced by sweet potato breeders without which other varieties needed by many consumers for various other uses may go into extinction.

REFERENCES

Agrodok, 28 CTA, (2013). P.O. Box 6700AJ, Wageningen. The Netherlands; Pp.35 - 37.

Ammirato PV and Yamada Y (eds) (2010). Handbook of plant cell culture. Volume 2. Crop species. Macmillan, New York; Pp. 302 - 306.

Dangler JM, Scheuerman RW, Campbell RN and Clark CA (1994). Meristem-tip culture and California's cleaning foundation sweet potato programme. Horttechnology; 4:227 - 228

Faber M and Benadè AJS (2002). A household food production programme and economic empowerment of rural women in South western Nigeria. The Nigerian Journal of Promotion of Sweet potato for the Food Industry in Nigeria 307 Rural Sociology, No(s). 1 and 2: 104-112.

FAO (2013). Food and Agriculture Organization of united Nation. Farm Management Extension Guilde; pp104

FAOSTAT (2017). farmer groups in Uganda to develop new sweet potato cultivars: decentralization and building on traditional approaches. Euphytica; 159: 217– 228. http://faostat.fao.org/site/336/default.aspx.

Henderson JHM, Phills BR and Whateley BT (1984). Sweet potato. In: Sharp, W.R., Evans, D.A.

IFPRI (2009). International Food Policy Research Institute.

Islam MJ, Haque MZ, Majunder UK, Haque MM and Hossain MF (2002). Growth and yield potentials of nine genotypes of sweet potato. Pakistan J. Biol. Sci., 5(5): 537-538.

Jeude JL (2004). Irene, K (ed). Identification of crop damage caused by pests or mineral deficiencies.

Kreuze J and Fuentes S (2008). Sweet potato Viruses. International Potato Center (CIP), Lima, Peru. ã Elsevier Publishers Ltd.

Kuo LG (1991). Conservation and distribution of sweet potato germplasm. In: Dodds, J.H (ed), in vitro Methods for Conservation of Plant Genetic Resources Chapman and Hall, London; Pp.123 - 149

Latruffe L (2010). Competitiveness, Productivity and Efficiency in the Agricultural and Agri-Food Sectors. OECD Food, Agriculture and Fisheries Papers, No. 30, OECD Publishing. http://dx.doi.org/10.1787/5km91nkdt6d6-en.

Loebenstein G, Thottapilly G, Fuentes S and Cohen J (2003). Virus and Photoplasma disease in: Virus and virus- like diseases of major Crops in developing countries. Academic Publishers; p.105

Low JW, Arimond M, Osman N, Cunguara B, Zano F and Tschirley D (2017). A food-based approach introducing orange-fleshed sweetpotatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. J. Nutr.; 137: 1320–1327

NACGRAB (2014). Crop varieties released and registered in Nigeria. National Centre for Genetic Resources and Biotechnology Moor; Plantation, Ibadan; pp.30-40.

Nwankwo IIM and Bassey EE (2013). Breeding Sweet potato for food in Nigeria. In: Contemporary issues in sustainable tropical Agriculture. Lawrence E., James, P.U., Nsikak-Abasi N.E., and Alice E.; Faculty of Agriculture, University of Uyo.

Odebode SO (2004). Acceptability of Sweet potato "sparri" and its potentials for enhancing food security

Onwueme IC and Sinha TO (1991), Field crop production in Tropical Africa, principles and practice. CTA (Technical Centre for Agriculture and Rural Cooperation), Ede. The Netherlands; Pp. 267-275.

Panta A, Espinoza C and Roza W (2007). Health status testing and virus elimination in sweet potato Available at: Hp//research.cip.cigar.org/confluence/download/attachment/1354/4 sweetpotato+virus/elmination.pdf?version=/clink checked 11march 2007

SASHA (2011). Sweet potato Action for Security and Health in Africa. Integrating health and agriculture to maximize the nutritional impact of orange-fleshed sweet potato: The Mama SASHA proof-of-concept in Western Kenya. Available http://sweetpotatoknowledge.org/projects-initiatives/sasha

Sorense KA (2009). Sweet potato insects. Identification, biology and management.

Suda I, Yoshimoto M and Yamakawa O (1999). Sweet Potato potentiality: Prevention for lifestyle-related disease induced by recent food habits in Japan. Food and Food Ingredients. J. Jpn., 181: 59-69

Sweet potato knowledge (2012). www.sweetpotatoknowledge.org May, 2012, accessed September 15th, 2013. Vitamin A deficiency: A South African experience. Paper presented at the VITAA Project.

Walter AII, Contrad KB and Philip AL (eds) (1992). Sweet potato technology for the 21st Century.

WHO (2011). World Health Organization. (www.who.int/caccines/diseases/en/vitamin/science/scio2ml). Accessed on 27/4/2019.

Appendix 1

Catalogue of Crop Varieties Released and Registered In Nigeria

S/N	Variety name	Original name	National code	Origin/source	Developing institute	Breeder/ collaborating scientist	Outstanding characteristics	Agro-ecological zone	Year of release	Year of register
1	TIS87/0087	TIS87/0087	NGIB01-1	IITA, Ibadan	IITA Ibadan	Dr. S. N. Hahn	widely adapted, dependable under any adverse condition, produces economic yield, for fries and chips, high tolerance to sweet potato weevil		1992	2001
2	TIS8164		NGIB01-2	IITA, Ibadan	IITA Ibadan	Dr. S.N Hahn	Very high root yielding, the top is highly cherished by livestock and fishes. Good for starch production.		1992	2001
3	TIS2532OP. 1.13		NGIB01-3	IITA, Ibadan	IITA Ibadan	Dr. S.N Hahn	Tuberous roots are very large with white flesh		1992	2001
4	UMUSPO/1	NRSP/05/022	NGIB01-4	NRCRI, Umudike	NRCRI, Umudike	Solomon Afuape, Innocent I.M. Nwankwo, Ted Carey, Chidozie Egesi, Jude Njoku, ThankGod N.C, Echendu and Jan Low	High beta-carotene, high dry matter, high root yield, and resistance to SPVD (63.63t/ha)	Rainforest and Northern Guinea Savanna	2012	2012
5	UMUSPW/2	NRSP/05/10D	NGIB01-05	NRCRI Umudike	NRCRI Umudike	Solomon Afuape, Innocent I.M. Nwankwo, Ted Carey, Chidozie Egesi, Jude Njoku, ThankGod N.C, Echendu and Jan Low	White fleshed with high dry matter, high yielding (44t/ha) and resistant to sweet potato virus diseases	Rainforest and Northern Guinea Savanna		

Appendix 1. Continue

6	UMUSPO/3	CIP440293	NGIB01-06	NRCRI Umudike	NRCRI Umudike	Solomon Afuape, Innocent I.M. Nwankwo, Ted Carey, Chidozie Egesi, Jude Njoku, ThankGod N.C, Echendu and Jan Low	Deep orange with high carotene content and high yield (56.4t/ha)	Southern Guinea and Northern Sudan Savanna	2013	2013

Source: (NACGRAB, 2014) Volume Number 6 as Updated as September 2014