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A Review of Production, Post-harvest Handling and Marketing of Sweetpotatoes in Kenya and Uganda

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ABSTRACT

Sweetpotato (*Ipomea batatas*) is a versatile crop that serves the roles of food and nutrition security, cash crop in both raw and processed forms. It is a source of livestock feed and has great potential as a raw material for industrial processing. The potential of sweetpotato has been greatly underexploited by the fact that it has been regarded as a poor man's food and is mainly grown under marginal conditions for subsistence by most producers, who are rural small-scale farmers in developing countries, such as Kenya and Uganda. Losses in the highly perishable root crop and its leaves are exacerbated by lack of appropriate postharvest knowledge, technologies and facilities. Inadequate information on available cultivars also limits the maximum utilization of the crop and leaves. The current review examines production potential, postharvest handling practices, marketing, and physicochemical and nutritional properties of sweetpotatoes.

Keywords: Storage, curing, consumption, harvesting, physicochemical properties.

INTRODUCTION

Sweetpotato is a starchy tuberous crop from the family *Convolvulaceae* along with common plants such as bindweed and morning glory. It is usually grown as an annual crop[1,2]. It is believed that *I. batatas* originated from the Central America then introduced to Europe by the Spaniards, from where it spread throughout the world[3]. It was first domesticated more than 5,000 years ago in Latin America and is presently grown more in developing countries than any other root crops[4]. It is believed to have arrived in Africa around the 20th century[2], and has been adopted by various communities, who utilize it differently. In Kenya and Uganda, as examples of East Africa, sweetpotato features in local foods. However, the distribution, production, postharvest handling, and marketing of sweetpotato in these countries have not been collated and subsequently examined systematically. To realize the full potential of sweetpotato in food and nutrition security in these countries, compilation of such information is a necessity.

Distribution of sweetpotato in the world

Sweetpotato (*Ipomoea batatas L.*) is grown in more than 110 countries of the world[5]. The crop accounted for about 12% of the world's root and tuber production with a total production of about 103 million tonnes in 2013[4]. It was ranked 9th in 2011 in terms of worldwide production after maize, rice, wheat, potatoes, soybean, cassava, tomatoes and bananas[4]. Based on total production, it's the 7th most important crop in developing countries[4] and is an important subsistence crop in East Africa[6]. It is also ranked the fifth most important crop in economic value in developing countries[7], sixth in dry matter production, seventh in energy production and ninth in protein production[8]. FAOSTAT indicated that about 80% of the world's total sweetpotato production is from the Asian continent while Africa accounts for about 20%. China is the world's leading sweetpotato producing country with about 70 million tonnes in 2013[4,9]. In Africa, Tanzania and Nigeria are the leading producers of sweet potato, while Uganda and Kenya are third and sixth producers respectively[9].

Sweet potato Production in Kenya and Uganda

Sweet potato is cultivated in 43 of the 47 counties in Kenya. Major production counties in 2014 in descending order were Bungoma, Homabay, Busia and Migori at 133,037, 127,725, 119,970, and 69,642 tonnes, respectively (Table1). Sweetpotato production in Kenya stood at 763,643 tonnes from 61,067 hectares in 2014 and it was valued at USD 0.23 Billion[10].

In Uganda, sweetpotato is grown country wide with the Eastern region having the highest production, and Kumi, Jinja, Kamuli, and Soroti are the major producing districts, with over 847,139 MT[11]. The Western region of Uganda is second in production with about 366,297 MT with Kabale, Bushenyi, Kyenjojo, Kisoro, Ntungamo, Kabarole, and Hoima districts as major producers. The Central region is third, and the major producers are Kalangala, Kayunga, Kiboga, Luwero, Mpigi, Mubende, Nakasongola, and Wakiso districts with a total production of 312,405 MT. Northern Uganda has the least production volume of 292,932 MT. Despite the low production in northern Uganda, most of the households depend on sweetpotato because of its hot climate, which does not favour growth of other food crops, thus making sweetpotato an important crop in Northern Uganda[11]. Some of the major producing districts of sweetpotatoes in Northern Uganda are Arua, Adjumani, Gulu, Oyam, Yumbe, Moyo, Lira, Apac, and Amuru[11]. Figure 1 shows the production trends of sweetpotato in Uganda.

In developed countries, sweetpotato is commercially grown as a high value vegetable crop under intensively managed conditions while in developing countries it is often grown under marginal conditions as subsistence or food security crop[4] It has been regarded as a 'poor man's crop' in Africa, with most of the production being small or subsistence level[8,12]. However, it is an excellent food security crop in sub-Saharan Africa because it often survives when other crops such as maize fail, it is less labor intensive than most other staple crops, it is vegetatively propagated and can be planted over a broad range of period without considerable yield loss[13]. In East Africa, sweetpotato is referred to as "the protector of children" because it is often the only food that stands between a child's survival and starvation[8]. It is widely grown throughout East Africa on a small scale mainly in subsistence farming and has been gaining popularity along with other indigenous foods[14]. It matures fast, is rich in nutrients and is often the first crop planted after a natural disaster, providing abundant food for otherwise starving populations. Limited land sizes in densely populated regions of Kenya has been noted as a constraint to production since most people have less than one acre on which to grow all the crops they need[15].

Sweetpotato is the third most important security crop in Uganda after banana and cassava[16], grown at least twice a year[17]. The crop is grown in all districts in Uganda occupying 55% of the arable land under tuber crops[18]. Sweetpotato is an important food and commercial crop[14]. In Kumi district, 99% of the women farmers reported that they grow it for both food and commercial purposes, while most of the male farmers grow it for income. UBOS[11] observed that in the face of raising global food prices, sweetpotato is proving to be the best food secure and famine crop. During peak harvest periods of September to November, prices drop as low as USD 6 per 120 kg bag, but can hike to as high as USD 36 during scarcity months of February to June[11].

Contribution of sweetpotato to the economy

The Kenya agricultural sector directly contributes 26% of the gross domestic product (GDP) annually and another 25% indirectly (Table 2). The sector provides more than 70% of informal employment in the rural areas and hence the means of livelihood for the majority of Kenyan people in addition to being the driver of Kenya economy[19]. Growing of crops contributed about 20% to Kenya's GDP with Sweetpotato contributing about 0.42% in the year 2014[10]. On the other hand, agriculture contributes 21.9% to the Gross National Product (GNP) of Uganda[20]. Sweetpotato contributed 4.4% to gross agricultural production value in Uganda9.

Consumption of sweetpotato

Sweetpotato is one of the world's most important food crops in terms of human consumption, especially in Sub-Saharan Africa (SSA), parts of Asia and the Pacific Islands[4]. The world average per capita consumption (kg) of sweetpotato was recorded as 7.97, 8.01, and 8.22 for the years 2011, 2010 and 2009, respectively[9]. Per capita per year consumption varies between 90 – 100 kg in Uganda and about 24 kg in Kenya mainly consumed boiled or fried[15,22].

Many villages in East Africa depend on sweetpotato for food security[8]. There has been a sharp increase (300%) in consumption of sweetpotatoes in Kenya from 2012 to 2014. Currently, sweetpotato production trends are changing as most people now grow it for both food and commercial purposes, due to increasing demand and prices attached to it. The crop has more commercial market especially in schools, hospitals, prisons and other institutions. Reports from FoodNet Uganda and sweetpotato trading associations indicate that during general food security, the crop becomes the most preferred crop for both rural and urban households especially by the low income dwellers. Sweetpotato is therefore a food crop enjoyed by all classes of people.

Agronomical aspects of sweetpotato production

Sweetpotato is a highly adaptable crop that tolerates high temperature, low soil fertility and drought[23]. It produces tubers without fertilizers and irrigation but does not tolerate frost[8]. The crop is grown in various agro-ecological zones from sea level to 2200 m above sea level at between latitudes 48°N and 40°S, it requires warm to hot weather with temperature ranges of 15°C to 35°C[24], relatively high light intensity and average rainfall of 750-1000 mm per annum[25]. Sweetpotatoes have the shortest growing periods out of all the major root crops[2], with majority of the cultivars maturing in three to four months[24], meaning that it can be grown twice a year[25]. Average yields differ greatly in different areas or even fields in the same location mainly due to variation in quality of the propagation material[8]. Average yields in Kenya are estimated to be between 4 and 9 tonnes per acre[24], and in Uganda, yields are about 4.5 tonnes per hectare on average[26].

Main growing seasons of sweetpotato

Sweetpotatoes are fairly drought resistant[2] and grow well in hot humid climates normally flower in summer[27]. In western Kenya (Busia, Bungoma and Kakamega counties), sweetpotato is grown in two planting seasons per year, March/April and August/September, both of which coincide with the long and short rains, respectively[15]. In Uganda, the growing seasons and harvesting time for the sweetpotato are very diverse. This is mainly due to the differences in rain distribution throughout the different regions (Table 3).

Main cultivars and origin of sweetpotatoes grown in Kenya and Uganda'

Many cultivars are available (Table 4 and Figure 3) mainly differentiated by colour and shape[2]. The flesh colour of the tubers varies from various shades of white, cream, yellow to dark orange depending on the carotenoids content[30]. About 40 new orange flesh sweetpotato (OFSP) cultivars introduced to Africa were evaluated and accepted by the farmers and consumers and are currently promoted in Tanzania, Uganda, Kenya, Mozambique, and South Africa, in addition to the local popular landraces[31]. Some OFSP cultivars grown in Uganda and Kenya include SPK 004 (Kakamega), NASPOT 9-0 (VITAA, SPK004/6), NASPOT 10-0 (Kabode, SPK004/6/6) and Ejumula[32]. The yellow fleshed cultivars include Naspot 1 and Tanzania, while white fleshed cultivars include Dimbuka, Nakakande, New Kawogo and Ndikirya N'omwami[33]. Their popularity varies with regions.

In developed countries, where sweetpotato is used more as a vegetable or for sweet dishes, the red-or orange-fleshed types are preferred for their moist flesh and sweet flavor, and phytochemicals[8]. African producers and consumers prefer starchy, high dry matter and sweetpotato cultivars with resistance to viruses and weevils. The adoption will be higher if the OFSP cultivars find ready markets, both as fresh roots and vines and as processed foods with added value[31]. Studies by Kivuva *et al.*[24] revealed that farmers in central, eastern and western Kenya preferred sweetpotato cultivars Vitaa, Kemb 10 and Kabode because of their orange flesh with high beta carotene. Small-scale farmers in sub-Saharan Africa prefer cultivars that have high dry matter content[35], low fibre and good taste, especially women farmers. Most preferred genotypes of sweetpotato by farmers in Kenya have qualities like orange flesh, high dry matter (favourable starch and sugar content), low fibre content, do not overcook in normal cooking time and are high yielding[24]. Another study on sweetpotato cultivar selection in Kenya by Were *et al.*[15] revealed that farmers' top criteria in Busia, Kakamega, Bungoma and Butere-Mumias were taste, yield and maturity period followed by disease or pest resistance, availability of planting material and lastly market preference.

In Uganda, OFSP is mainly grown for its perceived nutritional benefits and the monetary value attached to it, but is disliked by the farmers because of its high perishability and vulnerability to harsh conditions, low dry matter content and the lower sweet taste. The white fleshed sweetpotato cultivars, especially Kawogo, Dimbuka, Sukali, and Tanzania are most preferred by farmers. This is so because of their ability to resist harsh conditions, they have a high dry matter content and have sweet taste. Over 86% of sweetpotato farmers in Uganda grow these cultivars and are mainly used as fresh roots, and making amukeke (dried white fleshed slices) and kasende (sweetpotato flour)[36].

Factors hindering use of certified/ quality seed for cultivation

Lack of enough clean planting materials (serious problem) and high cost of inputs have been cited by farmers as hindrances to use of certified or quality seed[24]. Lack of extension services for new technologies, agronomic packages and marketing prospects for the crop were noted as constraints[15], in addition to the presence of pests and diseases. Many farmers in Uganda have expressed demand for virus-free vines especially for the farmer-preferred cultivars and farmers are now relying on the subsidized public sector and non-government distribution systems. This kind of supply is unreliable but leaves farmers with no option since there are no decentralized vine producers with commercial orientation. In Uganda, the total sweetpotato vine requirement is about 7.8 bags per farmer per year. Most of these farmers are willing to offer more for virus free vines[36], but there is lack of decentralized sweetpotato vine producers, who can supply year round virus-free sweetpotato vines.

Main Pests and diseases occurring in the vegetative period

Sweetpotato incurs high yield losses in production due to biotic (insect pests and diseases) and abiotic (drought and heat) constraints[24]. Sweetpotatoes are vegetatively propagated from vines, root slips (sprouts) or tubers, and farmers in African and other countries often take vines for propagation from their own fields year after year[8]. Thus, if virus diseases are present in the field, they will inevitably be transmitted with the propagation material to the newly planted field, resulting in a decreased yield[8]. There are about 20 viruses or virus like diseases, about 35 bacterial and fungal diseases, about 20 nematodes and about 20 insect pests that affect sweetpotato[24]. Sweetpotato virus disease (SPVD) is a common disease in key sweetpotato agro-ecologies in East and Central Africa, and especially around Lake Victoria where it affects most of the introduced clones as well as some of the local landraces[31]. Other diseases that may infest SP include potato mosaic disease, fusariun surface rot, fusarium root rot, black scurf, black rot and leaf rust[25].

Viral diseases that have been reported in some Western Kenya regions and Uganda include[15,37,38]:

a. Sweetpotato feathery mottle virus (SPFMV) of genus Potyvirus family Potyviridae which is transmitted by aphids.
b. Sweetpotato chlorotic stunt virus (SPCSV) in the genus Crinivirus family Closteroviridae, transmitted by whiteflies. This appears to be very common occurring as a single infection and combined with others, which can cause

severe symptoms.

c. Sweetpotato mild mottle virus (SPMMV), genus Ipomovirus, family Potyviridae, transmitted by whiteflies.
d. Sweetpotato chlorotic fleck virus (SPCFV). This is a Carlavirus transmitted by unknown vectors.
e. Sweetpotato latent virus (SwPLV).
f. Sweetpotato caulimo-like virus (SPCaLV).
g. Cucumber mosaic virus (CMV).
h. SP virus disease (SPVD) caused by the co-infection of SPCSV and SPFMV. This is the most serious viral disease infecting sweetpotato in Uganda, and its symptoms include small, distorted leaves which are often narrow and crinkled, and general stunting of plants.

Sweetpotato weevil was noted as a major pest in Kenya[24]. Other pests include sweetpotato white fly and vine borer, as well as rodents[15,25].

Harvesting of Sweetpotatoes

Maturity Indices

Harvesting usually begins three to four months after planting depending on cultivar. Maturity indices may include yellowing and drying of the lower leaves, and cracking of the soil indicating presence of tubers[25]. In Uganda, for instance, farmers take the principle maturity measurement for sweetpotato as root size. The average root size in the field is judged by removing the soil around several randomly selected plants in different locations within the farm. The farmers use hands to remove soil from the mounds to check the size of the roots[28].

Harvesting methods

Piecemeal harvesting, where only enough is taken for one or two meals, is a common practice for home consumption and small-scale marketing[39]. Mature roots, harvested from the mound, make room for additional roots to develop. The process of piecemeal harvesting can continue for about three months, again depending on the cultivar and conditions, but after that time any roots remaining in the soil will succumb to sweetpotato weevil attacks or other pests, or otherwise deteriorate. The harvesting of roots close to or protruding from the ground might, however, help deter weevil attacks[29].

Harvesting of sweetpotato in Kenya has traditionally been done by use of blunt objects, mainly a wooden stick specially carved so as to minimize physical injury to the tubers, especially for piecemeal harvesting. The tubers are also dug up using hoes in wholesale harvesting for commercial purposes[25] or when land is required for planting another crop[15]. Many farmers in Kenya practise piecemeal harvesting[24] to allow continuous and steady harvest, preserve vines for future planting and because of lack of modern storage facilities and ready market for produce[15]. They are, however, harvested once in large farms, sliced into small chips and dried to avoid deterioration and for value addition[15]. Data on piecemeal harvested crops such as sweetpotato are difficult to collect[14], and hence not easy to quantify yields from the particular farms.

In many parts of Uganda especially the western region and central, sweetpotato vines are cut off near the soil before the intended harvest date. During the dry season, the vines are removed three to seven days before digging. Removing the vines helps to toughen the skin of the root. The vines are removed manually with a sickle or knife. During the rainy season, the vines are left intact until the day of harvest. Roots exposed to wet soil conditions without the intact vines are most at a risk of postharvest diseases[40].

After removing the vines, the sweetpotato roots are dug using a blunt stick and or hand hoe or oxen plough. Manual harvesting of sweetpotatoes is typically done using a stick fork which is used to loosen the soil and undercut the roots[40]. Care is taken to avoid cutting or injuring the roots. The roots are then lifted out of the ground, separated from the main stem and temporarily left on the top of the soil or put directly into a sack for transportation.

Post-harvest handling of sweetpotatoes

Packaging

Sweetpotato is perishable and bulky to transport, and packaging is one of the major steps in post-harvest handling of sweetpotatoes. Due to the fact that piece meal harvesting is common in Kenya and Uganda, most of the sweetpotato is packaged in baskets or sacs depending on the availability and distance of transportation. There are no developed specific packaging technologies for sweetpotato in

Kenya. Traders commonly pack the commodity in gunny bags/sacs, which are susceptible to physical damage, attack from pests and microorganisms and unfavorable environmental conditions especially during transport to longer destinations. Use of poor quality packages, and rough handling are known to result in physical and quality losses[41] at the producer, wholesaler, and retailer levels. Appropriate packaging equipment and containers are required not only to facilitate safe transport of sweetpotato, but also for storage of low volume produce and for product presentation at the markets. In Uganda, the roots are roughly forced into overfilled sacs with an extension so that a 100 kg bag holds 120 kg, and brokers make extra profit at the farm gate price[14,39].

The role of packaging of sweetpotato (and other materials), is to protect the roots from undesirable weather conditions, facilitate other processes of storage, supply of the roots, marketing and safety in transportation. Good packaging technologies should address a number of concerns, amongst which have sufficient strength in compression and against impact and vibrations, stability during the value chain, should be reasonably affordable, durable, and easily printable (helps to advertise the products).

Uganda has adequate and well-distributed rainfall allowing annual production and continuous harvesting, thus farmers believe that there is little need for sophisticated packaging. However, in the drier northern areas of Uganda, especially where cassava has been threatened by mosaic disease, good packaging of fresh sweetpotato roots for longer periods of storage could help alleviate a potentially

Table 1: Sweet potato 3 year production trends in leading counties of Kenya

Year County	2012 Area (ha)	 Production (tons)	2013 Area (ha)	 Production (tons)	2014 Area (ha)	 Production (tons)
Bungoma	3,857	53,274	5,836	135,250	5,499	133,037
Busia	9,593	88,010	6,712	138,230	6,395	119,970
Homabay	7,440	131,300	4,612	68,805	7,839	127,725
Migori	11,835	183,525	10,496	52,168	10,995	69,641.50

Source: ERA[10]

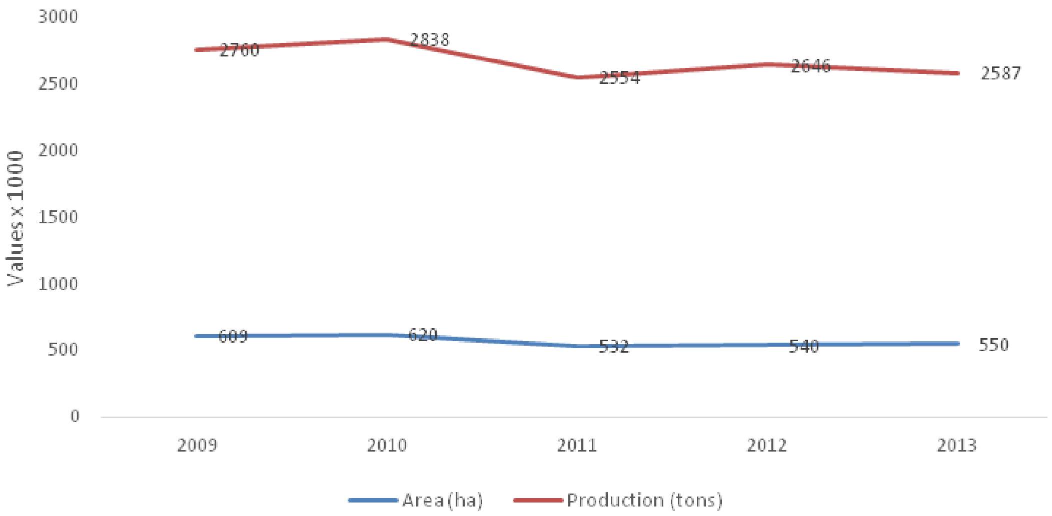

Fig. 1: Five year production trends of sweetpotatoes in Uganda. Source: FAOSTAT[9]

serious food shortage. This is critical in the months of May to June, because these are months of high harvests. However, farmers only have access to baskets, sacks and cut plastic vessels such as jelly cans[42].

Transportation of roots

The harvested roots are normally transported in large synthetic sacs but they provide little protection and can cause root skinning during loading, transportation and unloading. The packed sweetpotato roots intended for market, are transported using bicycle or pick-up depending on destination[43]. For home consumption, since it is always a piece meal, head carriage is used as a form of transportations, and this kind of labour is offered by women and children.

Damage or losses during handling

Post-harvest losses of fruits and vegetables before they reach the consumers are estimated to be between 30% and 40%[44]. Physical and quality losses are mainly due to poor temperature management, use of poor quality packages, rough handling, and a general lack of education regarding the needs for maintaining quality and safety of perishables at the producer, wholesaler, and retailer levels[41]. Physical and quality losses in turn lead to loss of market value, concerns about food safety, and lower incomes for growers[41]. Insufficient and poorly maintained transport and market infrastructure for handling food products in urban and rural areas have frequently resulted in high level of waste and spoilage[45].

Most farmers who produce the crop are smallholders, who do it primarily at subsistence

Table 2: Kenya's Gross Domestic Product (GDP) at market prices (Million Kenya shillings) by activity

Industry Contribution	2010	2011	2012	2013	2014
GDP at market prices	3,169,301	3,725,918	4,261,151	4,730,801	5,357,672
Agric., Forestry & fisheries	786,909	980,088	1,113,860	1,250,991	1,464,310
Crops	530,841	686,088	765,579	875,090	1,057,882
Sweetpotato	7,400	20,700	26,700	20,900	22,500

Source: KNBS[21]

Table 3: Major growing seasons of sweetpotatoes by region in Uganda

Region/district	Planting season	Harvesting season
Central eastern (Kumi, Amuria, Soroti, Iganga)	Late February to early June and early August	Late October
Eastern (Mbale)	March throughout season	
South eastern (Tororo)	Late March through April	
Central (Luwero and Mpigi)	Late February to early May and April to early August	Early July to late October
Western Uganda (Kabale, Kisoro)	Late April to July and late August to Early November	Early June to August and Early November to late December
Northern Uganda (Gulu, Lira)	Late February ot late June	Early July to late October

Source: Bashaasha et al.[28] and Zorogastua[29] level such that market supply will depend on the availability of the surplus within the households[14]. There is therefore hardly enough or surplus to warrant storage for longer periods. Uganda registers about 15% loss during harvest because of the technologies used in harvesting and packaging. As highlighted above, most of the farmers use hoes for harvesting and most of the roots get cut or bruised, which cause damage and stress to the roots. The uncut roots are de-skinned during packaging and transportation which cause serious bruising[43]. The packaging sacks are also over stacked with sweetpotatoes and this imposes more damage to the roots.

Other important post-harvest handling practices

Curing

Curing is the most important stage in handling harvested tubers as it determines the keeping time and quality of the fresh tubers[1]. Curing of the tubers facilitates healing of the wounds incurred during harvest and extends the postharvest life of the roots as well as reduces moisture loss and microbial decay during long-term storage[3]. Once cured, sweetpotatoes can be stored for several months and white fleshed cultivars for as long as ten months[39]. Curing reduces shrinkage and minimizes weight loss during storage[1] as well as enhancing

Table 4: Main cultivated potato cultivars and their origin

Cultivars	Origin of cultivar	Growing region
Tanzania, New Kawogo, and Wagabolige Malawi	Superior Ugandan farmers' cultivars (Soroti district mainly), assembled at Namulonge Agricultural and Animal production Research Institute (NAARI).	Central eastern Uganda and Northern parts of Uganda. Tanzania is also know to originate from
Katalaako	Iganga district, Uganda	Eastern Uganda
Odeyo cani, bwomdege and cwara opoko	Gulu district, Uganda	Central eastern Uganda
Tororo 1,2 and 3	Tororo district of Uganda	Central eastern Uganda
Kidera, Katalaako	Iganga district, Uganda	Common in eastern Uganda
Butalenja	Local cultivar	Common in eastern Uganda
Naigongera	Ugandan farmers' cultivar	Common in southern and eastern Uganda
Yellow fleshed cultivars, NASPOT (11, 9, 3, 10, 8, 6, 4, 7, 5, 2 and 1), Dimbuka/ Bukulula, Kakamega, Kabode and Ejumula	Released by National Crop Resources Research Institute (NACRRI) of Uganda Sweetpotato Programme.	All parts of Uganda and Western Kenya. Origin is International Potato Centre.
Dimbuka, bugerere, sikali, Sukali, Mwezigumu, nylon, mpaeifumbiro and Wagabolige	Jinja district, Uganda. Favorite farmers' cultivar	Central Uganda especially Mpigi, Luwero and Nakasongola
Kawogo, Nantongo and mweziguma	Mpigi district, Uganda	Central Uganda and Eastern
Sowola (NIS/90/389a) Source: RTB[34]	The progenitors in this polycross block were popular Farmers' cultivar from various parts of Uganda	Throughout Ugandan sweetpotato growing regions.

the eating quality by decreasing the starch content and increasing the sugar content. Traditional curing involved stacking potatoes in the field or garden, covering them with sand and leaving them for several weeks. There was also a recorded use of heat in curing of sweetpotatoes in a constructed sweetpotato cellar where a smoky fire was made every day for three to four weeks[46].

Curing sweetpotato can be done using several methods e.g. open air-sun, greenhouse solar, hot air cross flow, shade drying, vacuum-freeze drying, osmotic dehydration among many others[47]. Some of these methods involve advanced technologies, and are not technically or economically suitable for African farmers. Sub-Saharan Africa is known for high ambient temperatures[42] thus, tubers can possibly be left in the field after de-vining and before harvest in the hot, humid times of the year, which is similar to the curing room environment[1]. Prior pruning for wholesale harvesting can be done by removing sweetpotato canopy 14 days before harvesting to reduce the amount of moisture to facilitate long storage periods after harvest[25]. Pre-harvest curing carried out in Tanzania by the Natural Research Institute (NRI) involved removing sweetpotato foliage 14 days before harvesting, and this was claimed to result in reduction of postharvest losses by up to 40%[14]. In Uganda and Tanzania, sun drying has been used for along time to dry sweetpotato to extend shelf- life for up to six months[39].

Different curing regimes are applied in commercial production; sweetpotatoes can be cured in rooms with humidity between 75 – 80% and temperatures between 27 ^{O}C and 30 ^{O}C for a week to ten days[46] or conducted at 32 °C and 90-95% relative humidity for 5-7 days to facilitate healing of the wounds incurred during harvest and extend the postharvest life of the roots[4,48] . The roots can be put into storage at 30-32°C and 90-95% relative humidity for 4 to 10 days[1] after which the temperature is dropped to 15.6°C for long term storage, keeping the same relative humidity.

It can be deduced from above that temperature, humidity and holding times are critical in curing of sweetpotatoes. The benefits of curing sweetpotato lie in extending its storage stability, and this is crucial for food and nutrition security. However, information on curing of sweetpotato in Kenya and Uganda is relatively limited or non-existent.

Storage of sweetpotatoes

Storage of dried sweetpotato has become a practice of increasing importance. In Uganda, storage is in the form of either dried slices known as *amukeke* or *kaseede,* or in dried crushed form known as *inginyo*[39,49]. Sweetpotato slices can generally be stored for as long as four to six months, and in crushed form for somewhat longer, though both are at risk from infestation by grain borers due to poor packaging.

Long-term storage of fresh roots has been attempted on an experimental basis in Soroti, in the mid Northeastern region of Uganda, with the participation of local farmers using below-ground pits, above-ground clamps with conical thatched roofs, and wooden boxes kept indoors[42]. Ash and other materials have also been used to extend storage life An optimal mix of storage techniques and cultivars is necessary to store fresh sweetpotatoes for up to three months, or long enough to make a difference when local food security is most uncertain[42].

Typically, sweetpotatoes are stored and eaten fresh. However, there are some simple methods used to increase their storability that can be used in conjunction with other storage methods[42]. Drying of tubers is done on those that are too damaged to be stored fresh but still have edible material on them. This involves slicing tubers to a thickness of approximately 2–4 mm and then laying them out in the sun for four days or until they are rid of most of their moisture. During drying the potatoes can be covered in prickly bushes or thorns to ward off animals. Dried slices can be kept in-doors or in raised silos until eaten. Drying removes moisture, reduces bacterial growth, and inactivates metabolic processes and enzymatic decomposition[50].

The ultimate aims of storage are to ensure food security during off-season, regulate commodity in the market in an orderly way and management of glut to saving producers and traders from selling products under duress of market forces. However, the tubers are highly perishable when not stored in favourable conditions because of their high moisture contents especially the orange fleshed cultivars[14]. The endogenous enzymes in sweetpotatoes are responsible for the breakdown of starch into sugars during storage[51], and this makes storage of the fresh sweetpotato tubers beyond three months difficult[52]. Use of good quality roots free of damage, and disease, and avoiding temperature build-up in the stores were found to be the main factors that improve storability of fresh sweetpotato under tropical conditions in Tanzania[52]. The management of temperature and relative humidity are therefore primary factors in the storage life of sweetpotato. Reducing postharvest losses of mature produce is more sustainable than increasing production to compensate for these losses[41]. Losses occurring after harvest of sweetpotato are costly since costs of production have been already incurred. Sweetpotatoes need to be stored for up to a year in order to sustainably supply and maintain their markets[52]; however, in developing countries, with limited resources and a crop of marginal value, storage is not commonly practised[52].

Tubers can also be left in mounts and harvested piecemeal or can be harvested and stored in a pit or clamp stores on a bed of dry grass[25] In Tanzania, low cost storage pits and clamps with thatched roofs can store roots up to four months[14].

Sweetpotato storage in Kenya is generally insignificant and can probably be identified by either producers (who are also consumers) or traders in the market since there has always been inadequate production to supply the market. Between 68% - 90% of farmers in Western Kenya did not know how to store surplus sweetpotato tubers[15]. Lack of commodity stores for sweetpotato hinders production and value chain sustainability. A lot of emphasis has for a long time been placed on cereal crops, leading to the establishment of the Kenyan National Cereals and Produce Board (NCPB) that buys, stores and markets excess cereals from the farmers. Moreover, lack of market infrastructure negatively impacts on food security, safety and keeping qualities of sweetpotato. This is because most food markets in Kenya do not have properly designed stalls for traders to utilize, thus sweetpotato is mainly spread on the ground and exposed to the hot sun throughout, until they are sold out or otherwise be disposed due to rapid spoilage.

Technological advancement in modern day has the potential of modifying the environment for storage in rooms or containers. The understanding of the physiological changes in OFSP during storage is paramount to the development of storage technologies. Sweetpotato can be kept in cool dry well ventilated rooms or containers (baskets are ideal for small household volumes) at about 55°F to 60°F (13°C to 16°C).

In research conducted by Okonya *et al.*[53], it was established that majority of the farmers in Uganda store sweetpotatoes for less than a week. The two most popular short-term storage methods are on the floor in the house or in baskets. Most of the white fleshed cultivars can be stored either in pits or in clamps (covered above ground mounds) for up to 19 weeks. The stored potatoes still are consumed in piecemeal, and remaining roots are processed into dried chunks or slices (*amukeke*). Some farmers in Eastern Uganda store roots in the pits for an average of 38 days, although some claim to store them up to 138 days[54] .

Common storage methods for sweetpotatoes
Naturally ventilated store

There is sufficient movement of cool air through a heap of potatoes to remove respiratory heat and keep the potatoes as cool as ambient temperatures can allow. The design is based on the principle of natural air convection. This type of store was introduced by the extension programmes of FAO for farmers in the highland areas of Kaborole, Kabale, and Kisoro. Generally, the structure is a mudlock structure, 1.2 m long, 1.2 m wide and 1.0 m high to the eaves with a thatched roof and a capacity of about 700 kg. The capacity could be increased by making the store longer. The lower part of the store is ventilation chamber made over a pit about 35cm deep into which is a stone foundation wall of 15cm deep to support a mud block wall on the spaced 2-3 cm apart and laid over the stone wall to make a ventilating floor. On the windward side of the structure, a ventilation opening is fitted with a shutter to control ventilation. The storage section can be made from false floor up to the eaves at 1m high and can be provided with closable openings for loading and emptying. The roof structure is of raffia or wood material covered with grass[55].

In ground storage

This is commonly done by subsistence farmers, sweetpotatoes are commonly left in the ground and eaten or sold directly following harvest, this is called piece-meal or sequential harvesting. In ground storage is used to protect the fresh tubers while reducing the work required to set up storage facilities. In drier places such as northern Uganda, leaving sweetpotatoes in ground is not a suitable method and practical solution, and hence the farmers produce dried white fleshed sweetpotato slices (*amukeke*) [42].

Pit storage

This is a simple, cheap method that involves digging a hole in the ground for storing the potatoes. The pit storage differs from in ground as tubers are collected and kept together and considerations are made to control the storage environment. Construction of the pit can vary according to what materials are available but commonly used are; grass, soil, wood, lime, sawdust and ash. Grass is typically used to line the bottom and sides of the pit in order to insulate against temperature change and moisture absorption[56]. Before usage, grass should be flamed in order to destroy any pests that may be hiding within. Soil is used to seal the roof of the pit and as filler. Wood and plant material can be used to strengthen walls as well as create a roof covering the pit. Roofs built over the pit structure are beneficial in that they can help keep rain out and provide shade to lower temperature. Lime may have some effectiveness in absorbing carbon dioxide and removing it from the environment. Sawdust is used as a cushioning material and to help control condensation on the roots. Wood ash can be applied to potatoes prior to storage and has shown some effectiveness in protecting against insect attacks and mould.

Clamp and mound storage

This is another simple and low cost method, clamp storage consists of covered piles of sweetpotatoes. After selecting for the roots in the best condition, they are stacked in a heap on a layer of grass and covered in layers of grass and soil. As with pit storage, ash, lime and sawdust can be used for added effects. The piles may be made at ground level or in shallow or deep trenches. Drainage is considered and ruts may be made in the ground to lead off water. The clamps may be covered by a roof or kept in a building for added protection. To minimize losses due to respiration, a ventilation shaft can be added. Results are fairly poor with this technique and estimated storage time is 2–3 months[42].

Indoor storage

Sweetpotatoes may be harvested and stored in building. This could include in the living area or in a granary built specifically to store produce. In home storage is typically done in straw woven baskets, cloth bags or wooden boxes. Baskets and boxes have been shown to be more effective at minimizing mechanical damage. If possible tubers should be kept off the ground to keep them away from rodents and other pests[57]. This is an effective technique for maintaining proper ventilation, though depending on the type of building, maintaining proper storage temperature and RH may be difficult. Granaries or other storage buildings typically consist of a round hut with walls made of straw, mud, clay and wood and a conical straw roof. These are commonly supported above ground by a system of legs to keep the crop dry and away from animals, rodents and pests[57].

Effect of storage on quality of sweetpotato

Storage under tropical conditions has been shown not to affect the texture characteristics and overall changes in sweetpotato, with special reference to orange fleshed sweet potatoes (OFSP)[58]. The provitamin A carotenoid (pVAC) retention of staple crops during storage reached levels as low as 20% after one to four months of storage and was highly dependent on genotype[59]. Short durations of four weeks storage at a low temperature (5°C) was found to significantly increase phenolic compound concentration and antioxidant activity in sweetpotatoes, and these increased significantly when low temperature-stored roots were transferred to ambient temperature (about 22 °C). However, it was also noted that non-cured tubers accumulated a higher phenolic content and antioxidant activity than cured roots. A brief period (about three weeks) of low temperature storage may significantly increase phenolic content and antioxidant activity without causing a loss in root marketability[3]. An experimental in Uganda showed that storage of tubers of Ejumula and *SPK004/6/6* in a pit at (17-21°C, RH 90-100%) resulted in a higher retention of beta carotene compared to those stored at ambient conditions (24-27 °C, 68-100 %rh) and in saw dust at (19-23°C, RH 86-100%). The farmers in Uganda reported storage losses amounting to approximately 27% of total output. There are no current research results which show the new trend of sweetpotato storage in Uganda. Farmers find it difficult to store sweetpotato because of *Cylas formicarius*, sweetpotato weevil and its related species, and this has prevented a sustained investment in storage facilities[40]. Because of this threat, majority of Ugandan farmers leave the roots in the ground and harvest it only when there is need.

Utilization of Sweetpotato

Fresh sweetpotatoes having relatively high moisture contents are very sensitive to microbial spoilage, even at refrigerated conditions. Hence, they must be consumed within a few weeks after harvest or be processed into various products. Utilization of sweetpotato has been limited to their traditional uses[60], though they have tremendous flexibility of utilization as food, feed and industrial products[8]. They are mainly used as human food; tubers are mainly consumed boiled or fried[22]. Use of vines as fodder and leaves as a vegetable is common in some parts of Western Kenya[15]. According to the country's Economic Survey 2015 report by the Kenya National Bureau of Statistics (KNBS), sweetpotato tubers in Kenya are utilized 90% domestically as human food. Over 80% of the Ugandan farmers employ in-ground storage and piece meal harvesting strategies, it is hard to determine the sweetpotato harvested for fresh market and therefore, there is no data available[43,54]. Once roots are mature, they remain stored in the ground for up to six months. Farmers begin harvesting large roots three months after planting and as the roots mature, leaving the plant intact to produce more roots. In piece meal harvesting, farmers harvest only the sweetpotatoes needed for immediate sale.

Marketing of sweetpotatoes
Domestic Marketing

Were *et al.*[15] noted that 40 - 60% of the sweetpotato produce in western Kenya was marketed. Kenyan sweetpotato is domestically marketed from late September to February. Locally processed products (boiled roots and flour) by community groups are sold to supermarkets and to shops in local markets[15].

In Uganda, farmers generally sell about 17% of their total harvest. The majority of sweetpotatoes are produced for home consumption, although many farmers market at least some of their crop. About 53% of farmers sell some of the portion of the sweetpotato crop. Of these, about 71% sell fresh sweetpotatoes at the farm gate, 43% at roadside markets, 38% at rural markets, and 8% in urban markets (% exceed 100 because some farmers are involved in all forms of marketing) [43]. Since marketing of sweetpotatoes is done mainly at farm gate, there is no cooperative marketing. Almost all marketing is done at individual basis. There are several losses which are incurred during marketing and the major causes of these losses include limited market, poor postharvest handling methods, weevil attack in stores and seasonal variations[28].

International Trade

The International trade of sweetpotatoes in the year 2011 was 267,000 MT valued at USD 210.5M[61] with Canada being the main importer and the U.S.A being the main exporter. Other importing countries are United Kingdom, Netherlands, Japan, and Italy[62], while other exporting countries are China, Netherlands, Dominican Republic and Lao People's Democratic Republic[61]. Despite Uganda being one of the largest producers of sweetpotatoes, it is not involved in the export market[9]. This could be attributed to the fact that the areas which have the potential to generate surpluses are relatively localized but dispersed, which leads to a lack of market integration and limits market size. Moreover, production is highly seasonal leading to marked variations in quantity and quality of roots, and associated price swings. There is also limited commercial processing into chips or flours, which could be stored for year round consumption and use in bread and cakes or processing into fermented and dried products. These factors have led to unstable market for sweetpotato and thus farmers stick to sporadic local marketing, and on target marketing which makes it also hard to penetrate export market[63].

There are, however, no recorded exports of sweetpotato and its products by Kenya, according to the Economic survey report of the KNBS[21]. Sweetpotato tubers are usually imported from Tanzania by wholesalers to Kenya between June and August, when sweetpotato is scarce in Kenya[64]. Export trade in Uganda is mainly informal and majorly concentrated at the borders of Rwanda and D.R. Congo. This kind of trade is illegal and there are no captured statistics[11].

Processing sweetpotatoes

Development of low and intermediate technologies that will process sweetpotato into value added products at the household and village factory levels would promote its production and consumption and increase its economic value[60]. Sweetpotato can be used to brew alcoholic beverages and processed into products like chips, crisps, flakes, granules, and starch[2]. Sweetpotato processing in rural areas of Kenya is mainly done by women/community group members having been trained on the processing technologies by the district home economists and make different products including traditional ones like *mandazi bhajia*, amongst others[15]. In general, the production volume of sweetpotato in Kenya is too low to support sustained supply of raw commodity for industrial processing[9]. Processing by community groups is limited to three months period in a year when sweetpotatoes are available[15]. There are however, scanty national data on the number of processors, volume of sweetpotato processed and profit margins for the processors[1]. Sweetpotato leaves can be processed into powders that can be used as functional ingredients in food products such as ice cream, juices, tea drinks, and bread due to their high phenolic content and antioxidant activity[65].

Most of the value addition done on sweet potato, is cultivar-based. Orange Fleshed SweetPotato is currently getting popular in Uganda because of its high β-carotene content, and its potential to reduce Vitamin A deficiency. OFSP was introduced in Uganda in the year 2007 by HarvestPlus, a part of Consultative Group on International Agriculture Research (CGIAR) Program on Agriculture for Nutrition and Health. Other bodies which have promoted the production, value addition and promoting utilization of OFSP in Uganda are; USAID, CIP, Feed the Future, the government of Uganda through NARO and other institutions. Value addition or processing has been done as a way of diversifying the utilization patterns of the sweetpotato and technology has been disseminated to local farmers especially women but no entrepreneur has taken it up for commercialization. More so, most of the sales of sweetpotato in Uganda are confined largely to fresh tubers[54,66] .

A large range of products known to trained farmers include composite flours, chapatti, mandazi, juice, bread, doughnuts, and other confectionary products. Other products produced by the local farmers in Uganda are; pit stored tubers, *amukeke* (dry white slices), *inginyo* (dry chips, chunks), amukeke flour and *inginyo* flour[54]. Market options for sweetpotato products like chips, flour, and starch have been explored. However, the last available documentation of these market analyses suggests that the market is still very limited. Sweetpotato chips are not commonly traded beyond household sales and there is no available information following up on the market test for the new products like sweetpotato flours

Farmers consume most of the total harvest as fresh tubers from their own farms with about 30% of farmers in Uganda, processing a portion of their harvests into *amukeke* slices. About 35% of *amukeke* producers sell a portion of their produce to the locals. These products are still used by the farmers to feed their families. The break through innovation for Uganda would be the mechanizing of sweetpotato production, selling of the processing technologies to entrepreneurs who can adopt the technologies and be ready for commercialization[66]. Therefore, the shift from giving the technologies to only local farmers and share it with already established entrepreneurs would be a great innovation both in Kenya and Uganda.

Physico-chemical and Nutritional traits of sweetpotato cultivar

Physical Properties of sweetpotatoes

Sweetpotatoes vary enormously in taste, size, shape, and texture. The flesh can be white, orange, yellow, purple, 'red, pink or violet[8] while skin color varies among white, yellow, red, orange, and purple[22]. Cultivars with pale yellow or white flesh are less sweet and moist than those with red, pink, or orange flesh. They also have little or no beta-carotene and higher levels of dry matter, which means their textures are drier and mealier and they stay firmer when cooked[8]. The orange-and red-fleshed forms of sweetpotato are particularly high in β-carotene, the vitamin A precursor[13].

Nutritional aspects of sweet potatoes

There is a gap in the nutritional profiling of sweetpotato cultivars in Uganda and Kenya, much of the work has been done on the Orange Fleshed Sweetpotato in Uganda with major emphasis being beta-carotene content (Table 5).

Sweetpotato (SP) is best known for its carbohydrate content, the predominant form of it being starch[2], and are good sources of dietary fibre[30]. The tubers are largely rich sources of energy about 440 kJ per 100 g of edible portion. SP is a good source of vitamins C (ascorbic acid) and B[4]. They also contain minerals as well as an assortment of phytochemicals[2]. Sweetpotato and its leaves are good sources of antioxidants[27], fiber, zinc, potassium, sodium, manganese, calcium, magnesium, iron and vitamin C[27].The orange and yellow cultivars have high carotenoids content[2]. Improved OFSP cultivars have been shown to have high content of all-*trans*-β-carotene and are particularly important in combating Vitamin A Deficiency (VAD) in SSA[13]. The purple sweetpotato colour is rich in acetylated anthocyanins shown to minimize free radical production hence therapy for galactosemia[67].

Nutritional qualities of sweetpotato leaves

Sweetpotato leaves are edible and provide an important source of food in Africa, especially in Guinea, Sierra Leone and Liberia, as well as in East Asia[8] but have generally been regarded as an underexploited green vegetable in Africa. They are also used as fodder and browse for sheep, goats, cattle, pigs[68]. The leaves are an excellent source of antioxidative polyphenols like anthocyanins and phenolic acids such as caffeic, monocafeoylquinic (chlorogenic), dicaffeoylquinic, and tricaffeoylquinic acids[65]. Sweetpotato leaf is also rich in vitamin B, carotenes, iron, calcium, zinc and protein[65]. The leaf has the highest total phenolic acid content in the plant, followed by the peel, whole root and flesh tissues[69]. A lot of studies has focused on the roots, and relatively little is known about the chemical composition and nutritional importance of the leaf.

Physico-chemical properties

Dry matter content

Sweetpotato is known to have a relatively low dry matter content, between 13 and 50%[14], and this varies widely depending on factors such as cultivar, location, climate, day length, soil, pests and diseases and cultivation practices[22]. They are rich in starch 6 – 30% wet basis or 50 – 80% dry basis[70]. Starch is important as a raw material or thickener, stabilizer or texture The acceptable level of storage root dry matter is lower in Southern than in Eastern Africa; about 27% versus 30% respectively[14]. Low dry matter of most of orange fleshed cultivars is a challenge towards their adoption and production by farmers[35].

Mineral constituents of sweetpotato roots

Sweetpotato roots and leaf are rich in various mineral elements, whose concentration depends on cultivar, location and agronomical conditions. A study on four cultivars in Rwanda showed the ash content ranged from 0.4% to 0.44%[22]. Generally, OFSP is rich in Fe (50 ppm DM) and Zn (40 ppm DM) (Kivuva *et al*., 2014). Cultivars grown in Vihiga County in Kenya showed iron content (mg/100 g) ranges of 1.10 - 1.30, 1.28 – 1.30, 1.03 – 1.28, and 1.28 – 1.40 for the white, purple, yellow, and orange flesh cultivars respectively and calcium (mg/100 g) ranges of 25.30 – 26.0, 18.50 – 24.43, 24.75 – 27.35, and 21.28 – 24.31 for white, purple, yellow and orange flesh cultivars[71].

Chemical constituents of sweetpotato leaves

Depending on genotypes and growing conditions, the average contents of minerals and vitamins in recently developed cultivars 'Suioh' were 117 mg calcium, 1.8 mg iron, 3.5 mg carotene, 7.2 mg vitamin C, 1.6 mg vitamin E, and 0.56 mg vitamin K/100 g fresh weight of leaves (Islam, 2006). Leaves of seven cultivars of OFSP in Ghana contained iron and calcium contents ranging from 9.62 – 23.02 mg/100g and 1310.52 – 1402.27 mg/100g respectively[68], while the minerals composition of the leaves grown in Tepi area of Ethiopia revealed potassium (3609 mg/100 g), sodium (32 mg/100 g), calcium (320 mg/100 g), magnesium (119 mg/100 g), copper (1.8 mg/100 g), zinc (6 mg/100 g), iron (74 mg/100 g), and manganese (10 mg/100 g)[72]. The nutritional value and consumption of sweetpotato leaves in Kenya have not been accorded enough research attention to encourage maximum utilization.

Reducing sugars

Sucrose is the most abundant sugar in raw SP tubers with smaller amounts of glucose and fructose[22]. The levels of these sugars is significant in processing because, at high frying temperatures a Maillard reaction occurs between these sugars and amino acids yielding dark-colored bitter tasting products[73]. Besides at high temperature and longtime frying, acrylamide formation could be influenced by the concentration of these reducing sugars and asparagines in the tubers. During storage of tubers, some starch is converted to reducing sugars and subsequently into sucrose[22]. Cultivars from the South Pacific region were found to have total sugars ranging from 0.38 to 5.64% fresh weight basis and from 2.9% to 5.5% (fwb) in American cultivars depending on time of harvest[22]. A study on four cultivars of SP in Rwanda showed the content of reducing sugars range from 1.74 to 2.5%[22]. It is suggested that the acceptable upper limit of reducing sugars content to obtain acceptable processing color is 0.25 - 0.5% of fresh weight. Tubers are still considered acceptable for processing if the reducing sugars do not exceed 2% on dry weight basis[73].

Carotenoids in sweetpotatoes

Carotenoids have been credited with several health-promoting effects: immune enhancement and a reduced risk of developing degenerative diseases, such as cancer, cardiovascular diseases, cataract, and mascular degeneration[74]. Orange fleshed cultivars are dominantly rich in proVitamin A carotenoids[16]. Some OFSP cultivars have yielded about 8000 µg β-carotene per 100g of fresh weight. Among the carotenoids, α-carotene and β-carotene have a high provitamin A activity[74]. Some studies on raw peeled tubers of Kenyan OFSP cultivars have yielded beta carotene ranges between 1240 – 10,800 µg/100g fresh weight. Carotenoids are known to undergo degradation when exposed to heat and light[47] and through various processing methods including cooking[30]. There is, therefore, the need to handle sweetpotato to minimize loss of carotenoids.

Functional properties of sweetpotato

Pasting properties of sweetpotato are defined with its starch which is the major carbohydrate in its dry matter content[70]. As a major food component on a worldwide scale and one of the main food ingredients, both in native or modified forms[75], starch is widely used as a thickener, a gelling agent, a bulking agent and a water retention agent[76]. Pure starch is a white, tasteless and odorless powder that is insoluble in cold water or alcohol and generally contains 20 to 25% amylose and 75 to 80% amylopectin by weight depending on the plant[77]. Amylose acts both as diluents and inhibitor of swelling, especially in the presence of lipids which can form insoluble complexes with some of the amylose during swelling and gelatinization. The physicochemical properties of starches depend on the botanical source from which they are isolated; the major botanical and commercial sources of starches being cereals, tubers, roots, and legumes[76]. Swelling power and solubility, paste viscosity, retrogradation, gelatinization temperature, paste clarity and freeze-thaw stability are important physico-chemical properties of starch that determine its utilization in the food processing[78]. The swelling power for starch is affected by presence of reducing sugars in starch hence unavailability of total starch for water absorption[77]. Starch granules are usually densely packed with amylose and amylopectin in a semi-crystalline state with inter and intra-molecular bonds; are insoluble in water and are often resistant to chemicals and enzymes hence making it more easier for amylase enzymes to act on gelatinized starch than raw starch granules[75].

Starch from sweetpotato is more free swelling and non-congealing besides, exhibits a Type A Brabender amylograph characterized by a high pasting peak followed by rapid and major thinning on cooling[79]. This limits its utilization in products that require starches with faster retrogradation rates like starch noodle[80]. Swelling power and solubility, paste viscosity, retrogradation, gelatinization temperature, paste clarity and freeze-thaw stability are important physico-chemical properties utilized in the food processing[81]. The swelling power for starch is affected by presence of reducing sugars in starch hence unavailability of total starch for water absorption[77]. Starch granules are usually densely packed with amylose and amylopectin in a semi-crystalline state with inter and intra-molecular bonds; are insoluble in water and are often resistant to chemicals and enzymes hence making it more easier for amylase enzymes to act on gelatinized starch than raw starch granules[75].

The amylose/amylopectin ratio of sweetpotato starch have been shown to influence the physicochemical properties of flour like gelatinization, retrogradation, water absorption and pasting viscosities[51]. High amylose content in flours has been shown to influence high resistance towards swelling hence high pasting temperatures[82]. Low amylose content on the other hand enhances the water binding capacity of gelatinized starch[83]. Amylose content differs among the different SP cultivars, and even within the same cultivar, probably due to agricultural practices, genotype and environmental conditions[84].

Gelatinization of starch granules has been reported to increase their susceptibility to the action of hydrolytic enzymes such as α-amylase[84]. α-amylase, β-amylase and starch phosphorylase are some of the endogenous amylolytic enzymes contained in the sweetpotato that are responsible for hydrolytic effect and the breakdown of starch into sugars during processing[51]. Hydrolysis of sweetpotato starch by α-amylase yields mixture of different saccharides (maltodextrines) with different precise composition for commercial markets in the food and pharmaceutical industries[84]. Due to differences in genotype, environment and cultivation practices[14], endogenous enzyme activity of OFSP roots may vary greatly from the fresh tubers to the stored, from season to season and from source obtained.

OFSP have been shown to exhibit a lower pH than the white, yellow and cream cultivars. High pH has been reported to increase solubility of starch in flour by increasing the hydrophilic character of starch in the flour[51]. OFSP flours have exhibited high pasting peaks and rapid thinning[51]. High starch viscosity is an indication of good quality starch while low viscosity could imply some degree of degradation of starch during processing[85]. Starch from different OFSP cultivars could display differences in peak viscosities as has been shown by cultivars from Uganda (Table 6). Differences in amylose content and genetic variation have been reported to induce differences in pasting and viscoelastic characteristics of starch[86]. There is a great likelihood that the many cultivars of SP produced by farmers in Kenya could be inherently different in their physicochemical and resultant functional properties, thus the need for characterization of the white, yellow and orange cultivars.

Knowledge gaps

- There exists insufficient data on postharvest practices like curing, current storage methods, and processing and market information on sweetpotato tubers in Kenya.
- Knowledge and consumption statistics regarding sweetpotato leaves in Kenya is scarce.
- There exist several cultivars of sweetpotato in Kenya and Uganda but studies on characterization of the nutritional and physicochemical properties of their tubers and leaves for maximum utilization and functionality in food processing is grossly limited.

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