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A Review on Post-Harvest Profile of Sweet Potato

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A B S T R A C T

Due to rapid increase in demand for grain both as food and feed, there is an urgent need substitution of grain starch with other starch substrate like sweet potato for food security and bioenergy production.Sweet potato,a bio-efficient crop grown for edible roots has spread into Africa, Asia, Europe and East Indies through Batatas line and to the Philippines from Central and South America. Sweet potatoes may be harvested whenever they reach a marketable size. Under good growing conditions, harvesting may begin 90 to 100 days after planting of some varieties and continue until well after frost has killed the vines and leaves. Sweet potatoes should be stored between 12 and 16°C (54 and 61°F) with a RH of 80-95% and proper ventilation during storage to maximize potential storage time. Respiration causes the production of CO_2, which will act to increase the rate of spoilage. Thus Sweet potato possess unique physic-chemical characteristics of starch for value addition and industrial use.

Introduction

The sweet potato (*Ipomoea batatas*) is a native American plant found by Columbus and his shipmates, probably on the West Indies islands of the coast of Yucatan and Honduras. Despite its name, the sweet potato is not related to the potato. Sweet potatoes belong to the morning glory family, while potatoes are members of the Solanaceae family. Sweet potatoes became popular very early in the islands of the Pacific Ocean, spreading from Polynesia to Japan and the Philippines. One reason is that they were a reliable crop in cases of crop failure of other staple foods because of typhoon flooding.

They are featured in many favourite dishes in Japan, Taiwan, the Philippines, and other island nations. Indonesia, Vietnam, India, and some other Asian countries are also large sweet potato growers (Onwueme, 1978).

Early records have indicated that the sweet potato is a staple food source for many indigenous populations in Central and South Americas, Ryukyu Island, Africa, the Caribbean, the Maori people, Hawaiians, and Papua New Guineans. Protein contents of sweet potato leaves and roots range from 4.0% to 27.0% and 1.0% to 9.0%, respectively. The sweet potato could be considered as an excellent novel source of natural health-promoting compounds, such as β-carotene and anthocyanins, for the functional food market. Also, the high concentration of anthocyanin and β-carotene in sweet potato, combined with the high stability of the color extract make it a promising and healthier alternative to synthetic coloring agents in food systems (Bovell-Benjamin, 2007).

In agriculture, post harvest handling is the stage of crop production immediately following harvest, including cooling, cleaning, sorting and packaging. The instant a crop is removed from the ground, or separated from its parent plant, it begins to deteriorate. Post harvest treatment largely determines final quality, whether a crop is sold for fresh consumption or used as an ingredient in a processed food product (Woolfe, 1992).

Harvesting and Handling

Sweet potatoes have thin, delicate skin that is easily damaged by cuts and abrasion (Mukunyadzi, 2003). Striking the roots with harvesting equipment or dropping them into containers injures their skin. Bruises and abrasions must be kept at a minimum. The sweet potato may be cut or bruised if they are placed in containers having sharp edges or roughly hauled or handled (Sumner, 1984). Impact loggers located at the centre of sacks indicated that the most severe impacts (greater than 20g) occurred during unloading and loading from road vehicles and ships. However, skinning injury and broken roots were correlated with a large number of minor impacts (2 g or lower).The use of cardboard boxes filled with fewer roots instead of overfilled polypropylene sacks and adoption of improved management procedures in the handling and transport are recommended (Tomlins *et al.*, 2003).

Curing

Curing to promote wound healing is found as the most suitable method to control microbial spoilage. Curing naturally occurs in tropical climates where mean day temperature during sweet potato harvesting season (February–April) invariably remains at 32–35°C and relative humidity at 80–95%. Sweet potato varieties varied in their root dry matter content and low root dry matter content attributed for their high curing efficiency. Curing efficiency of varieties also differed in response to curing periods (Ray and Ravi, 2007). Sumner, 1984, reported that, sufficient exchange of air in the curing room should be allowed to prevent the accumulation of carbon dioxide produced by the roots or depletion of oxygen consumed by them. If condensation is excessive, it is removed by ventilation. The primary purpose of curing is to heal injuries so that the sweet potatoes remain in good condition for marketing during the winter and to preserve "seed" roots for the next crop. Healing takes place rapidly at 85 degrees Fahrenheit and 85 to 90 percent relative humidity. Curing should start as soon after harvest as possible to heal injuries before disease-producing organisms gain entrance. Healing involves production of cells that are very much like the skin in their ability to prevent infection. According to Mukunyadzi, 2009, some benefits and problems associated with curing are mentioned below:

Benefits of curing

Curing enhances culinary characteristics such as combination of color, texture, aroma and fiber content. Proper curing has been shown to increase the sensation of moistness and sweetness, enhance the aroma and decrease the starch content while increasing the sugar.

Curing aids in wound healing and reduces losses due to shrinkage and disease.

Freshly harvested sweet potatoes have thin, delicate skin that is easily broken, scraped or otherwise removed, thus curing helps to set the skin.

Problems associated with improper curing

Inadequate and excessive curing can shorten shelf life, increase sprouting during storage and result in excessive weight loss. Normal weight loss should not exceed 5-8% of the freshly harvested weight.

Improper ventilation during curing can result in an extremely low oxygen or high carbon dioxide environment.

Curing at improper temperature and humidity can reduce quality during storage. Low humidity also results in inadequate healing of wounds.

Curing that continues for too long can result in wide spread sprouting. It is not unusual to see short (less than one-fourth inch) sprout buds on a few roots toward the end of curing. However, wide spread sprouting results in rapid weight loss.

Storage

The next step for production of high quality sweet potatoes is the storage in the proper environment. The primary goal of the storage is to maintain root quality and ensure an adequate supply throughout the year by minimizing both physiological disorders and disease development. Low temperature stress-induced phenolic compounds may increase the antioxidant activity as well as the nutraceutical value of sweet potatoes [*Ipomoea batatas* (L.) Lam].

Cured and non-cured roots of 'Beauregard' sweet potatoes were exposed to low temperature storage (5 °C) for up to 4 weeks. A significant increase in total phenolic content in cured and non-cured roots was observed after 2 weeks of low temperature exposure. However, an increase in the antioxidant activity after 3 weeks of storage at 5 °C was noticed only in non-cured roots. After 4 weeks of storage at 5 °C, non-cured roots accumulated higher total phenolics and antioxidant activity than cured roots. Among tissue locations, the highest phenolic content and antioxidant activity were found in the periderm tissue and the lowest in the pith tissue. A 3-day exposure period to ambient temperature (~22 °C) following low temperature storage resulted in a significant increase in antioxidant activity in periderm tissue (Padda and Picha, 2007).

Sweet potato storage roots are subjected to several forms of post harvest spoilage in the tropical climate during transportation from field to market and during storage. These are due to mechanical injury, weight loss, sprouting, and pests and diseases. Sweet potato weevil is the single most important storage pest in tropical regions for which no control measures or resistant variety are yet available. Several microorganisms (mostly fungi) have been found to induce spoilage in sweet potatoes during storage.

The most important among them are *Botryodiplodia theobromae*, *Ceratocystis fimbriata*, *Fusarium* spp., and *Rhizopus oryzae*. The other less frequently occurring spoilage microorganisms include *Cochliobolus lunatus* (*Curvularia lunata*), *Macrophomina phaseolina*, *Sclerotium rolfsii*, *Rhizoctonia solani*, *Plenodomus destruens*. Microbial spoilage of sweet potato is found associated with decrease in starch, total sugar, organic acid (ascorbic acid and oxalic acid) contents with concomitant increase in polyphenols, ethylene, and in some instances phytoalexins (Ray and Ravi, 2007).

As reported by Mukunyadzi *et al*., (2009), Problems associated with improper storage conditions are as follows:

Sweet potatoes lose dry matter through natural respiration and pithiness is very common in sweet potatoes held for very long periods in poorly controlled storage facilities.

An effect of elevated storage temperature is sprouting. At temperature above 60ºF, sweet potatoes will sprout.

Storage below 50ºF can result in chilling injury.

If humidity is low, sweet potatoes will lose weight as moisture evaporates from the surface of roots. This results in weight loss and may cause shriveling of the skin especially at the root ends.

According to Grace *et al.,* (2013):

Purple sweet potato; NCPuR02-020, contained highest levels of all phenolic components.

A decrease in phenolic components was observed after curing and storage.

Covington contained the highest level of beta-carotene and total carotenoids.
Levels of carotenoids were significantly increased over curing and storage times.

Antioxidant activity and ascorbic acid gradually decreased with storage.

Packaging

The packaging of sweet potatoes is an industrial operation that should be dedicated to delivering the highest quality product to the consumer. The current market demands uniformity in appearance in both colour and size, which necessities long and complicated packaging lines. Unfortunately long packaging lines can increase the opportunity for skinning, bruises, cuts, and broken ends that detract from appearance and increase the possibility for disease development (Steed *et al.,* 2008).

Clark and Moyer 1988, gave some recommendation to reduce damage on packaging lines:

Dump roots slowly into water (not onto roots) in the dump tank.

Use high-quality padding on all impact surfaces.

Use long inclines to reduce drop heights between components.

Reduce the number of drops and turns.

Reduce the overall length of the packing line.

Remove belt supports (if feasible) to reduce impact.

Use deceleration flaps and blankets t reduce the speed over drops.

Instruct workers to handle roots with care, and monitor handling frequently.

Avoid abrupt changes in direction and speed of belts. Add padding if turns are avoidable.
Reduce packing line speed.

Shipping

An estimation shows that as much as 5 percent of packed sweet potatoes are lost annually during transportation to market. Much of the loss is a direct result of mishandling during shipment. To reduce losses, the shippers, truckers, and receivers should be well acquainted with the specific handling requirements of sweet potato. Packaged and palletized sweet potatoes awaiting shipment should be refrigerated at 55ºF and 85 percent relative humidity immediately after packaging (Mukunyadzi, 2009).

Marketing

According to Mukunyadzi, 2009 market life begins when roots are removed from bulk storage bins. Market life includes washing, packing, and distribution to market, and it concludes at the point of consumer purchase.

Table.1 Diseases Caused by Weevil Species

Name of the Pest	Description	Damage	Control or Solution
Sweet potato Weevils (Cylas spp.) (Coleoptera: Curculionidae)	Three species of the genus Cylas are pests of sweetpotato; they are commonly called sweetpotato weevils. All three species—Cylas formicarius, C. puncticollis, and C. brunneus—are found in Africa. C. formicarius is present in Asia and in parts of the Caribbean. The elongated ant-like adults of the three species can be distinguished from each other. In all species, the eggs are shiny and round. The legless larvae are white and curved, and the pupae are white.	Adult sweet potato weevils feed on the epidermis of vines and leaves. Adults also feed on the external surfaces of storage roots, causing round feeding punctures, The developing larvae of the weevil tunnel in the vines and storage roots, causing significant damage. Frass is deposited in the tunnels. In response to damage, storage roots produce toxic terpenes, which render storage roots inedible even at low concentrations and low levels of physical damage. Feeding inside the vines causes malformation, thickening, and cracking of the affected vine.	When sweet potato weevil populations are high, no single control method provides adequate protection. The integration of different techniques, with emphasis on the prevention of infestation, provides sustainable protection. Use of uninfested planting material, especially vine tips. Crop rotation. Removal of volunteer plants and crop debris (sanitation). Flooding the field for 24 hours after completing a harvest. Timely planting and prompt harvesting to avoid a dry period. Removal of alternate, wild hosts. Planting away from weevil-infested fields. Hilling-up of soil around the base of plants and filling in of soil cracks. Applying sufficient irrigation to prevent or

			reduce soil cracking.
West Indian Sweet potato Weevil (Euscepes postfasciatus) (Coleoptera: Curculionidae	Adult weevils are reddish brown to blackish gray, and are covered with short, stiff, erect bristles and scales. Eggs are grayish yellow to yellow. Larvae are white. Pupae are whitish and sedentary.	Adults feed on sweet potato stems and storage roots, and emerge by chewing exit holes. Larvae feed deep in the plant tissues. Internally, flesh and stem tissues are severely damaged. Affected roots are not edible by humans or animals.	Integrated pest management includes removal of infested sweet potato vines and storage roots from the field after harvest, removal of alternate hosts, and use of uninfested planting material. Biological control with B. bassiana and the use of early-maturing varieties also reduces damage.
Rough Sweet potato Weevil *Blosyrus* sp (Coleoptera: Curculionidae) l	Adult weevils are blackish or brownish and the surface of the elytra is ridged. This makes them look like a lump of soil. Larvae are whitish and C-shaped. Adult weevils lay eggs underneath fallen leaves. The larvae develop in the soil and pupate there. Adult weevils are found on the ground underneath foliage during the day	Adult weevils feed on foliage, but the larvae cause greater damage. While feeding under the soil surface, they gouge shallow channels on the enlarging storage roots. These "grooves" reduce marketability. When extensively damaged, the skin of the storage root has to be thickly peeled before eating, because the flesh discolours just under the grooves	Some of the cultural control measures used to control Cylas should be effective in reducing incidence of this pest, especially rotation and sanitation. The possibility of biological control is under investigation
White Grubs	White grubs, the larvae of various species of scarabid beetles, live in the soil. In the larval stage, they are large and fleshy with swollen abdomens, well-developed head capsules, and large jaws and thoracic legs	When they feed, white grubs gouge out broad, shallow depressions in sweet potato roots. Most species attack a wide range of host plants	Control is not usually necessary. Handpicking of exposed grubs during land preparation and weeding is useful. Light trapping can be used to control white grubs when they become a chronic problem in a localized area.

(Source: Ames *et al.*, 1997)

Table.2 General diseases of sweet potato

Name of the Diseases	Symptoms and Biology	Control or Solutions
Foot Rot (*Plenodomus destruens*)	Brown lesions form on the stem at or below the soil line. Wilting and death occur in severe cases. Black pycnidia can be seen.A canker extends down the stem and affects the proximal end of the storage root. This decay is dark brown, firm, and dry. The fungus does not survive well in the soil except in infected roots and stems. It is spread by infected cuttings, especially those from the base of the vine, and by contact with spores from infected roots in storage	Diseased roots should not be stored. Sanitation and the use of healthy vine tips for planting are the best means of control in the field
Java Black Rot (*Lasiodiplodia theobromae*)	This rot is firm and moist initially, but storage roots soon become totally blackened and mummified. Rot starts at either or both ends of the storage root and is initially brown, before turning black. Eruptive black stromatic masses that bear pycnidia are a diagnostic feature. Java black rot is spread by infested soil, infected storage roots, and contaminated storage boxes, baskets, or tools. Infection occurs via wounds, especially the cut stem end. Though the pathogen can infect stems, it grows very little and is seldom a problem	Timely harvesting can reduce losses. Good sanitation and care in handling to reduce wounding are important
Charcoal Rot (*Macrophomina phaseolina*)	This disease is found only on fleshy roots during storage. The fungus does not attack other plant parts. Infection starts on the surface of the root and progresses through the vascular ring toward the pith. Three distinct zones are found in a cross section of an infected root: an unblemished periderm, an inner zone about 6 mm wide of reddish brown tissue where a crusty layer of sclerotia is found, and the inner part of the root with light tan tissue. Sometimes the centre of the pith splits and the entire root becomes mummified	No control measures are known
Soft Rot (*Rhizopus stolonifer, Mucor*	Soft rotting occurs after harvest. Storage roots become soft, wet, and stringy, often starting at one end. A strong alcohol-like	Washing storage roots is especially conducive to rot. Care in handling and proper

sp.)	odour is produced. These fungi are commonly seen sporulating on the surface of rotting storage roots. The disease is spread by infested soil or air-borne spores that enter wounds. Optimum relative humidity and temperature for progress of infection and disease vary by variety, but are usually high. Soft rot can destroy harvested roots in 48 hours if they are left unprotected under sunlight.	curing can reduce disease incidence. So far, no resistance has been found, but some varieties rot faster than others because they are more susceptible. Curing is accomplished by storing after harvest at 29–32°C and 95–100% relative humidity for 5–7 days with adequate ventilation (at least 8 cubic feet of air per ton per day). Subsequent storage is best at around 13°C and95% relative humidity.

(Source: Ames *et al.*, 1997)

Table.3 Diseases caused by nematod species

Name of the Diseases	Symptoms and Biology	Control or Solution
Root-Knot Nematode (*Meloidogyne* spp.)	Affected plants become stunted, foliage turns yellow and flagging, and flower production is abnormal. On fibrous roots, round to spindle-shaped swellings (galls) are produced together with egg masses on the surface (Fig. 20). Large portions of the root system can become necrotic. The storage roots of some varieties react with longitudinal cracking (Fig. 21), whereas in others, blister-like protuberances emerge through the epidermis	Resistance, crop rotation (such as with rice in Asia), and selected nematode-free planting material can help to control this disease. In East Africa, nematodes are rarely associated with sweet potato and no control measures are needed.
Brown Ring (*Ditylenchus destructor)*	Fleshy roots, sometime after they are stored, show symptoms as depressed areas (Fig. 23). In cross sections, initial infections appear as necrotic isles of brown tissue scattered throughout the flesh. In advanced stages, the pulp becomes completely blackened, slightly soft, and corky (Fig. 24). These nematodes affect fleshy roots only during storage. No symptoms have been found in the field.	No control measures are known.
Reniform Nematode	Symptoms are not distinctive and	Rotation with non host crops

(*Rotylenchulus reniformis*)	can be confused with those caused by other nematodes. Affected plants are stunted because of destruction of fibrous roots. Foliage becomes chlorotic and transitorily wilted. Fleshy roots, when attacked early, develop cracks that enlarge as the roots grow. In mature roots, deep suberized cracks are the most noticeable symptom.	is recommended to reduce the soil population of the nematode.
Lesion Nematode (*Pratylenchus* spp.)	Affected plants are stunted because of a reduced feeder root system. On fibrous roots, lesion nematodes produce small, brown necrotic lesions. Affected fleshy roots also show blackish brown lesions that are often invaded by saprophytic fungi and bacteria	Organic amendments such as manure increase the natural enemies of the nematode in the soil and reduce its population. The use of resistant varieties is also recommended.

(Source: Ames *et al.*, 1997)

Table.4 Types of packaging for sweet potatoes

Types	Description
Corrugated Fiberboard	The most common container material. Relatively low in cost and easy to print with customized labels.
Plastic bags	A newer, low-cost material for consumer-sized packaging. Film bags are clear, allowing for easy inspection of the contents. They readily accept high-quality graphics and are available in a wide range of thickness, grades.
Shrink Wrap	One of the newer trends in packaging is shrink-wrapping of individual roots, which can reduce moisture loss, reduce mechanical damage during shipping, and provide a good surface for stick-on labels. Roots can be shrink-wrapped in a foam tray of two or three.
Net Bags	Net bags bundle roots into convenient consumer sized packages, they are preferred by many consumers as it limits the chance of diseases.
Bulk Bins	Large double or triple wall corrugated pallet bins are used as one-way pallet bins to ship in bulk form to processors and retailers.

(Source: Mukunyadzi., 2009)

Many factors influence the market life of sweet potatoes. The cultivar, pre-harvest growing conditions, curing conditions, storage temperature, relative humidity, atmospheric oxygen/carbon dioxide composition, amount of mechanical injury during transport and distribution to market are among the most important factors influencing market life.

In conclusion, the importance of proper handling of sweet potatoes from the farmer's field to the consumer's kitchen, cannot be over emphasized. Studies show that significant postharvest losses occur because of improper handling and other factors. On average 20 to 25 percent loss in sweet potatoes occurs during curing and storage, 5-15 percent during shipping and retailing and 10-15 percent after sweet potatoes reach the consumer. In total, poor handling practices may result in the loss of more than half of the harvested sweet potatoes before they reach the consumer's table. To provide consumers demand with an acceptable product, attention is required in the unique postharvest technologies of sweet potatoes.

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