Use of ambient conditions and sawdust in storage of sweetpotato (*Ipomoea batatas* L.) roots in Kenya

Running words : acceptability, East Africa, edible portion, moisture content, perishability, sprouting, shrivelling, and weight loss.

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Summary

Sweetpotato root storability and postharvest resistance to pests and diseases depend on varietal and storage conditions. However, little is known in regards to the storability of local Kenyan sweetpotato cultivars after harvest. Storage experiments in ambient conditions and in sawdust using 31 sweetpotato clones were conducted in order to identify the most rustic local varieties under natural storage conditions and to take advantage of a natural tropical environment that resembles artificial conditions in sweetpotato storage. Visual examination of edible portions in stored roots showed that varieties KEMB 7, KEMB 9, KEMB 10, KEMB 20, KEMB 24, KEMB 37, KSP 20, and KSP 119 were acceptable and did not rot after 5 weeks of storage in ambient air conditions. Storage in sawdust permitted the storage of roots up to 14 weeks (100 days) for most varieties. Although stored-root edible portion and colour were acceptable or good, sprouting was noted for almost all varieties. Shrivelling for KSP-type sweetpotato roots was lower than for the KEMB-type. It appears that moisture loss is an important determinant in storability and acceptability of roots and should therefore be minimised. These simple storage methods would extend the shelf life of the perishable sweetpotato for marketing and postharvest processing, and also help to release land for alternative utilisation after harvest.

Introduction

Sweetpotato (*Ipomoea batatas*) is an important subsistence crop in East Africa and plays a major role as a famine reserve for many rural and urban households due to its tolerance to drought, short growing period, and high yields with limited inputs on relatively marginal soils (Bashaasha, Mwanga, and Ocitti p'Obwoya, 1993; Ewell, 1993). Increasingly, it is the focus of interest for farmers, traders, researchers, and policymakers for cash and processing (Scott, Ferguson, and Herrera, 1992; Smit and Ocitti p'Obwoya, 1994). However, the lack of simple and appropriate medium- or long-term storage methods limits its marketing and postharvest processing.

Sweetpotato roots are highly perishable, and, in East Africa, they are not generally stored for extended periods after harvest (Karuri and Ojijo, 1994). The only kind of storage regularly practised in the region is in-ground storage, by which farmers keep unharvested mature sweetpotatoes in the field until they are needed for consumption or sale (Onwueme, 1982, Smit and Ocitti p'Obwoya, 1994). However, after maturation pest infestations by sweetpotato weevil (*Cyclas* spp.) become severe and cause production losses up to 50% (Ndamage, 1988). Mostly, sweetpotato is harvested piecemeal and consumed immediately after harvest without intermediate storage (Smit and Ocitti p'Obwoya, 1994; Winarmo, 1982).

Furthermore, sporadic use of rudimentary storage systems in traditional Kenyan communities (Ojijo, 1991; Karuri and Ojijo, 1994), and storage consisting of underground pits in Uganda (Devereau and Bockett, 1994), Malawi, and elsewhere in southern Africa (Woolfe, 1992), and covering with grass, on platforms or in baskets (Onwueme, 1982), have been reported. Sprouting and spoilage are usually common with these storage methods and the roots cannot be preserved well for a long time (Onwueme, 1982).

Roots intended for storage are generally harvested a little later than normal and are cured to harden the skin and hasten the healing of any surface wounds (Winarmo, 1982; Picha, 1987). Proper curing occurs ideally at 28-30C and 85-90% relative humidity for 4 to 7 days (Hamman, Miller, and Purcell, 1980; Picha, 1987). Curing is not practised in East Africa, but the normal temperature and relative humidity in the humid tropics are very similar to those required for curing, and some natural curing does occur (Reemer, 1990).

Fresh sweetpotato storage for several months (15.6C, 85% RH) is technically possible using artificial air-conditioned stores (Picha, 1987). But farmers in developing countries cannot afford these stores. Simple and cheap storage methods are required in this part of the world.

Sweetpotato has a broad genetic base, with tremendous variability (Woolfe, 1992) and many characteristics, such as storability, processing quality, and postharvest resistance to pests and diseases, that depend on variety (Scott et al., 1992; Gatumbi, Kihurani, and Skoglund, 1992; Shengwu, Chongwin, and Jinyu, 1994). However, most of these characteristics are still unkown for many local varieties.

There is interest in improving the shelf life of sweetpotato roots using an advantageous natural tropical environment. In this report, storage experiments in ambient conditions and in sawdust were conducted using 31 local sweetpotato varieties to identify the most rustic varieties under natural storage conditions.

Materials and Methods

Plant material

Fresh sweetpotato roots were provided by Dr. Haile Kidanemariam from the breeding service at the International Potato Center (CIP) Regional Office in Nairobi, Kenya. Thirty-one cultivars derived from germplasm maintained at the Katumani Dryland Research Station in Machakos District and the Kenya Agricultural Research Institute in Embu District were planted during the long rainy season of 1992 at the university farm of the Faculty of Agriculture in Kabete, Nairobi.

Curing

After harvest, the sweetpotato roots were wrapped in black polyethylene sheets exposed to full sunshine for up to 5 days. Temperatures achieved within the roots were as high as 30-35C, with high relative humidity retained due to moisture released by respiring roots. The roots were spread out on a concrete surface that retained and evened out the solar heat in the daytime. At night and during bad weather, roots were stored in an incubator set at 30C.

Ambient storage

Cured sweetpotato roots were carefully arranged with identification tags on a soft sisal sack on a laboratory bench. Roots were fully exposed to fluctuating ambient air conditions without protection from light. Fluctuations of ambient air characteristics in the experimental room were 17.4 to 23.3C and 90 to 93 % relative humidity for 100 days.

Storage in sawdust

Wooden structures measuring approximately 90 cm x 90 cm x 30 cm were fabricated using 2.5 cm boards. Dry sawdust from a local cypress timber saw mill was spread evenly to form a bed 10 cm in depth and roots were arranged on the bed with identification tags, before completely covering them with more sawdust. The structures were then overlaid with polyethylene sheets to help minimise ambient temperature fluctuation, and to check on moisture loss.

Moisture content determination

To minimise variation in root composition, a random sampling technique was adopted in order to include an assortment of all possible root sizes in the batch representing each cultivar. Batches differed in size distribution and number of roots. Moisture content was determined according to the procedure of Ranganna (1977), using the vacuum oven at 65C. Ten roots were randomly selected from each batch (to include all possible root sizes), washed, and then cut lengthwise into halves. One half was discarded and the remaining half portions were peeled and manually pulverized to give a suitable blend. Appropriate sample portions were weighed for the moisture content determination.

Firmness test

The half portions discarded in the moisture content determination were used for the firmness test. The hand-held penetrometer was used to puncture the root at three locations along the long axis, at the centre, and at both ends. The puncture force was read on the instrument and averaged for each sample.

Acceptability test

The stored roots were visually examined at regular intervals to check for sprouting, rotting, shrivelling, and pithiness.The roots were split both radially and lengthwise to assess pithiness. Rotten roots were unacceptable. Excessive sprouting, shrivelling, and pithiness could also render the root unacceptable purely from the point of view of physical appearance.

Storage weight loss

A representative number of healthy-looking roots were selected from every batch for moisture loss monitoring. This test was continued only with healthy roots. All rotting roots were discarded from the test whenever noticed.

Results and Discussion

Thirty one clones of sweetpotato roots were studied for storage characteristics using ambient air conditions and cypress sawdust.

Aspects of different sweetpotato root varieties after 5 weeks of storage in ambient air conditions are shown in Table 1. It was observed that perishability differs among cultivars, in agreement with report from Woolfe (1992), who noticed the tremendous variability in sweetpotato characteristics. The examination of the edible portion showed that varieties KEMB 7, KEMB 9, KEMB 10, KEMB 20, KEMB 24, KEMB 37, KSP 20, KSP 30, and KSP 119 did not rot, and their edible portion was generally acceptable after 5 weeks in storage (Table 1). Storage in ambient air conditions was inefficient for 21 varieties and their roots had been spoilt after 3 weeks in storage. The spoilage was accompanied by discoloration, ranging from brown to black, and then rotting. The major sweetpotato postharvest storage diseases in Kenya were described by Kihurani, Gatumbi, and Skoglund (1991) and consist of dry rots, soft rots, blue mould, and Java black rot.

It is interesting to observe that the popular variety in Kenya, KSP 20, was stored for 5 weeks in ambient air conditions, while farmers and traders always complain that it is not storable (Ewell, 1995, personal communication). This variety could be much more susceptible to bruising.

During and after harvesting, sweetpotato roots are extremely susceptible to skinning and bruising and often suffer mechanical injury at any time during handling and transport to urban centres because few precautions are taken. Gatumbi et al. (1992) reported that more than 90% of the sweetpotato root skin is lost during transportation and mishandling. The injured parts of the roots are thus attacked by various kinds of microorganisms and the root life is shortened. In agreement with Reemer (1990), it is possible in our experiment that natural curing was effective and wound layer formation completed or sweetpotato roots were carefully handled under laboratory conditions and were not highly bruised, as is common in East Africa.

Sawdust permitted the storage of sweetpotato roots up to 100 days and for most varieties the edible portion and color were acceptable or good (Table 2). The edible portion for KEMB 1, KEMB 10, KEMB 16, KEMB 20, KEMB 21, KEMB 28, KEMB 30, KSP 60, KSP 119, and KSP 186 was fair or poor. Pithiness was important for KEMB 28 but not much for KEMB 9, KEMB 10, KEMB 11, KEMB 16, KEMB 24, KEMB 27, KEMB 28, KEMB 30, KEMB 36, KSP 60, and KSP 97 (Table 2). After 20 days, all of the roots showed a fresh look except for KEMB 7, which had started to blacken, while KEMB 27 and KEMB 37 began to sprout (Table 3). However, these defects have a minor influence on the acceptability of the edible portion. It is a common practice in East Africa for farmers to remove the spoilt or damaged portion of the sweetpotato root and cook the rest (Smit, 1994, personal communication). Devereau and Bockett (1994) found that sprouting did not have a significant influence on the acceptability of stored sweetpotato roots.

KEMB-type roots were hard at harvesting and soft after 100 days of storage in sawdust, whereas the reverse happened with KSP-type roots (Table 2). Sweetpotato root hardiness varied erratically with storage.

Sprouting occurred with almost all varieties after 100 days of storage in sawdust except for KEMB 10, which shrivelled before reaching 100 days in storage. Sprouting was particularly important for KEMB 7, KEMB 11, KEMB 21, KEMB 23, KEMB 30, KSP 9, KSP 11, KSP 36, and KSP 185. Sawdust storage could be one solution to be considered in the production of sweetpotato planting material in semi-dry agroecological areas where, after the long and dry season, it is reported (Hagenimana, 1994) that sweetpotato planting material often comes from root pieces inadvertently remaining in soil during harvesting. By chance, when rain comes, these pieces begin to sprout. The use of sawdust in sprouting seems to be as efficient as vermiculite used by Hagenimana, Simard, and Vezina (1994).

Shrivelling was high for KEMB 9, KEMB 10, KEMB 20, and KEMB 30, and moderate for KEMB 1, KEMB 19, KEMB 27, KEMB 36, and KSP 5 (Table 2). In general, KSP-type varieties showed less shrivelling than KEMB types.

Roots with initially high moisture content (Table 3) are susceptible to shrivelling and to microorganism attack, and store badly. There is no evidence on the relationship between moisture content before storage and sprouting, but heavily sprouted roots have shown a significant weight loss after the appearance of sprouts (data not shown). Constant root moisture content during storage up to 100 days (Table 3) has a good correlation with acceptability and storability, and roots from varieties that were acceptable after 100 days were usually less susceptible to weight loss (Table 3).

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Table 1: Aspects of the edible portion of different sweetpotato root varieties stored in ambient conditions for 5 weeks.

Variety	Skin colour	Rotting	General acceptability
KEMB 1	dull grey	yes	not acceptable
KEMB 5 (Njuri Red)	white	no	acceptable
KEMB 6 (Mutukuri)	black all over	yes	not acceptable
KEMB 7 (Nduma)	purple-white	no	acceptable
KEMB 9	white	no	acceptable
KEMB 10	yellow	no	acceptable
KEMB 11	peripheral black	yes	not acceptable
KEMB 16 (Kaguri)	peripheral black	yes	not acceptable
KEMB 19	dull grey	yes	not acceptable
KEMB 20	white	no	acceptable
KEMB 21 (Mwondwe)	peripheral black	yes	not acceptable
KEMB 23 (Gikanda)	peripheral black	yes	not acceptable
KEMB 24 (Muhika na Ihu)	white	no	acceptable
KEMB 27 (Kahika na Ihu)	peripheral black	yes	not acceptable
KEMB 28	black all over	yes	not acceptable
KEMB 30	black all over	yes	not acceptable
KEMB 33	peripheral black	yes	not acceptable
KEMB 36 (Muibai)	peripheral black	yes	not acceptable
KEMB 37	black pith	no	acceptable
KEMB 39	peripheral black	yes	not acceptable
KSP 9	black all over	yes	not acceptable
KSP 11	peripheral black	yes	not acceptable
KSP 20	cream-white	no	acceptable
KSP 30	reddish yellow	no	acceptable
KSP 36	black all over	yes	not acceptable
KSP 60	black all over	yes	not acceptable
KSP 97	black all over	yes	not acceptable
KSP 119	white	no	acceptable
KSP 185	peripheral black	yes	not acceptable
KSP 186	dull (grey-white)	yes	not acceptable

Table 2: Aspects of different sweetpotato root varieties stored in sawdust for 100 days.

Variety	Sprouted %	Shrivelling %	Edible portion (%)	Edible portion color (%)	Edible portion pithiness	Hardness at harvesting (Kgf.)	Hardness after 100 days (Kgf.)
KEMB 1	80	60	40	fair	nil	168	133
KEMB 5 (Njuri Red)	75	25	75	acceptable	nil	148	130
KEMB 6 (Mutukuri)	30	20	80	acceptable	nil	190	119
KEMB 7 (Nduma)	100	20	80	good	nil	147	200
KEMB 9	25	75	25	acceptable	little	187	154
KEMB 10	0	100	0	-	-	176	161
KEMB 11	100	0	100	acceptable	very little	185	161
KEMB 16 (Kaguri)	75	25	75	fair	little	161	129
KEMB 19	25	50	50	acceptable	nil	167	163
KEMB 20	25	75	25	poor	nil	173	136
KEMB 21	100	25	75	poor	nil	190	110
KEMB 23 (Gikanda)	100	0	100	acceptable	nil	185	82
KEMB 24 (Muhika na Ihu)	75	0	100	acceptable	little	160	90
KEMB 27 (Kahika na Ihu)	50	50	50	acceptable	little	181	131
KEMB 28	50	25	75	poor	too much	183	149
KEMB 30	100	100	0	-	-	173	167
KEMB 33	50	0	100	acceptable	nil	168	143
KEMB 36 (Muibai)	50	50	50	acceptable	little	127	137
KEMB 37	75	25	75	good	nil	149	147
KEMB 39	50	0	100	good	nil	183	174
KSP 9	100	0	100	good	nil	143	199
KSP 11	100	0	100	acceptable	nil	134	144
KSP 20	50	10	90	acceptable	nil	123	139
KSP 30	25	0	100	acceptable	nil	120	178
KSP 36	100	0	100	acceptable	nil	155	170
KSP 60	25	25	75	fair	little	155	200
KSP 97	50	25	75	acceptable	little	179	171
KSP 119	50	50	50	poor	nil	139	167
KSP 185	100	0	100	acceptable	nil	150	134
KSP 186	60	30	70	fair	nil	147	163

Table 3: **Sweetpotato root moisture content and weight loss during storage in sawdust.**

Variety	Weight after 0 days (g)	Moisture Content at harvest %	Weight after 20 days (g)	Weight after 30 days (g)	Weight after 64 days (g)	Weight after 75 days (g)	Weight after 90 days (g)	Moisture content after 100 days storage (%)
KEMB 1	100	73.8	97.8 [a]	97.3	92.0	89.1	84.4	65
KEMB 5 (Njuri Red)	100	72.2	98.7 [c]	98.1	93.2	91.8	89.8	71.2
KEMB 6 (Mutukuri)	100	71.3	98.8 [a]	98.1	87.9	82.2	79.8	73.4
KEMB 7 (Nduma)	100	72.2	96.8 [b]	96.3	90.1	88.5	86.5	65.9
KEMB 8	100	83.3	92.5 [a]	90.9	84.3	82.3	79.0	78
KEMB 9	100	71.6	97.5 [a]	96.5	91.7	90.6	89.0	64.2
KEMB 10	100	68.1	97.0 [a]	96.2	88.7	86.4	83.7	68.1
KEMB 11	100	69.5	98.4 [a]	97.8	93.8	92.5	90.5	70.7
KEMB 16 (Kaguri)	100	75.8	96.9 [a]	95.2	88.3	86.1	83.0	78.8
KEMB 19	100	69.5	96.1 [a]	94.8	87.3	83.1	80.0	69
KEMB 20	100	75.8	98.0 [a]	96.5	90.4	88.4	86.5	72.9
KEMB 21 (Mwondwe)	100	67.5	96.4 [a]	95.7	86.7	83.7	78.9	78.5
KEMB 23 (Gikanda)	100	75.2	98.1 [a]	96.3	92.3	90.8	88.8	77.5
KEMB 24 (Muhika na Ihu)	100	69.8	97.7 [a]	97.4	91.5	90.0	87.9	67.4
KEMB 27 (Kahika na Ihu)	100	72	97.6 [c]	97.7	93.5	92.4	91.2	72.1
KEMB 28	100	70.6	98.1 [a]	97.7	90.5	88.4	85.4	68.2
KEMB 30	100	76.5	98.3 [a]	98.1	85.1	82.2	78.3	70.9
KEMB 33	100	67.3	97.8 [a]	97.1	91.8	90.0	87.1	67.4
KEMB 36 (Muibai)	100	75.8	97.7 [d]	95.7	88.4	85.9	82.6	67.6
KEMB 37	100	81	99.5 [a]	98.7	95.0	94.0	92.9	64.7
KEMB 39	100	65.6	86.7 [a]	86.2	81.5	79.9	77.6	66.3
KSP 9	100	67.3	96.7 [a]	95.4	90.2	88.3	85.4	63.4
KSP 11	100	73.6	98.9 [a]	97.4	92.8	91.2	89.4	73.9
KSP 20	100	77.5	98.2 [a]	96.9	93.9	93.0	91.9	76.8
KSP 30	100	71.1	98.9 [a]	98.7	95.2	94.3	93.2	70.3
KSP 36	100	64.1	97.6 [a]	97.3	91.2	89.2	86.6	65.1
KSP 60	100	66.9	96.5 [a]	93.6	87.9	86.3	83.7	60.2
KSP 97	100	69.4	95.9 [a]	91.5	87.3	85.5	83.1	64.2
KSP 119	100	66.2	96.8 [a]	95.3	75.3	73.8	71.6	64.8
KSP 185	100	72.7	98.2 [a]	98.0	93.5	91.7	89.0	69.7
KSP 186	100	72.2	96.6 [a]	94.8	83.0	79.5	74.8	65.2

[a] Fresh look, [b] Blackening, [c] Starting to sprout, [d] Heavily sprouted