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Effect of different storage methods on the shelf-life of fresh sweetpotatoes in Gairo, Tanzania

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Abstract. One of the major constraints to the potential of sweetpotatoes is its perishability commencing soon after harvesting. This is worsened by the lack of suitable storage methods as well as the difficulties to store improved varieties such as SPNO. This study was therefore intended to evaluate the storability of improved sweetpotato varieties and assess the effectiveness of selected storage methods under Tanzanian conditions. Four storage methods were investigated with 50kg of fresh injury free SPNO sweetpotato tubers. The storage methods covered under this study included traditional pit, improved open pit, improved housed pit (*mjinge*) and raised woven structure (*kihenge*). Results obtained from this study showed that housed pit storage (*mjinge*) performed comparatively well whereas the traditional method was the poorest in all attributes. For example, sugar content of sweetpotato stored using *mjinge* method increased significantly ($P<0.05$) from 6.25% to 9.25%. Although *kihenge* method performed well with respect to crude protein that increased from 4.90% to 6.06%, its performance in other attributes was poor. In addition, sweetpotatoes stored by *mjinge* method had good quality attributes of sweetness, starchy mouth feel, smell, colour and general acceptability, scoring between 3.37 and 4.19 in the hedonic scale (0- 5). Sweetpotato stored using this method could be processed for blending with cereals to make composite flours for porridge and also for making fried snacks. Efforts to tap the vast potential of sweetpotatoes are now underway through joint dissemination with the stakeholders.

Introduction

Sweetpotato (*Ipomoea batatas* L.) is one of the most important household food security crops in Tanzania. The crop complements other food crops and serves to bridge periods of food shortage before the next harvest of maize or other staple crops (Kapinga *et al.*, 1995). It is particularly a suitable food security crop as it produces high yields in a short growing season even under low rainfall (Kone, 1998; MOA, 1996 and Jana, 1982). According to Msabaha (1979) and Kapinga *et al.* (1995), sweetpotato is grown at all altitudes, on all kinds of soils, and in areas where annual rainfall varies between 800 and 1400 mm. In Tanzania, sweetpotato is cultivated by rural families and produced mainly by small-scale farmers. The crop is extensively produced in Shinyanga, Mara, Mwanza, Kagera, Tabora, Morogoro, and Mbeya regions. It is the third most important root and tuber crop in the country (after cassava and round potato), and is grown for home use and for sale (Kapinga *et al.*, 1995). Sweetpotatoes are bargain foods from the standpoint of both nutrition and monetary value. However, despite its potential, sweetpotato production is faced with serious post-harvest constraints, especially storage problems. This arises from lack of suitable storage methods. The situation is worse for improved varieties, which are high yielding and early maturing but difficult to store. Such newly developed high yielding varieties with poor storability include SPN/O, *Mwanamonde* and *Budagala* (Chilosa, 2000). The traditional pit storage method in which sweetpotato roots are treated with ash has proved to have deterioration effects on storage life and yet farmers use them for local varieties.

In SADC countries like Malawi, researchers have developed storage methods including pit storage in which roots treated with *dambo* sand are stored for a maximum of 3 months (Mbeza, 1996; Akoroda and Teri 1998). However, 3 months is still a relatively short period for storage. Farmers would wish to store their produce for longer periods. The lack of effective storage facilities forces farmers to dispose off their produce immediately after harvest (Akoroda, 1992). During off-season periods, farmers have little to sell and sometimes have little to consume. The practice of disposing off everything during the harvesting season results in a temporary glut in the market leading to low (give away) prices and adversely affecting the economic value of the crop. The main objective of this study was therefore to evaluate the storability of the improved sweetpotato varieties and assess the effectiveness of selected storage methods.

Materials and Methods

The study area. A storage site was identified and prepared at Ihenje village in Gairo division. Gairo division is in the north of Kilosa and experiences droughts with an annual rainfall less than 600 mm. The average annual temperature varies between 18°C on the mountains to 30°C in the river valleys.

Raw materials. Fresh roots of known sweetpotato cultivar (SPN/O), cultivated around Gairo were obtained. All roots were harvested on the same day, sorted, cleaned and stored in different conditions. Injured roots were excluded from the study.

Storage methods. Sweetpotato roots were stored using the traditional pit storage with some modifications. The storage time was set at three months from July to October. The different modifications on the pit storage method are described below:

Traditional pit storage with no other treatments. A pit measuring 1.5 x 1.8 x 1.2 m was prepared. A simple shed was constructed above the pit to protect the roots from direct sunlight. Some 50-kg of fresh sweet-potato roots were packed into the pit on the same day. No chemical or other substance was applied.

Improved open pit. A pit of the same size as described above was dug under shed. A layer of *dambo* sand (about 2 cm thick) was applied on the floor before packing the sweet-potato roots followed by sprinkling little amount of water. *Dambo* sand is inert fine sand from banks of seasonal rivers, and was obtained from a nearby river valley. The same treatment was repeated and subsequent layers of sweetpotato roots, each 12–15 cm thick added. A total of one litre of water and about 5 kg of *dambo* sand was applied per pit. The last layer of roots was covered with a 2-cm layer of *dambo* sand.

Improved housed pit (Mjinge). The design and size of the pit under *Mjinge* storage was similar to the one used for the improved open pit. The only diffrence in this design was addition of a small hut above it The hut, measuring 1.8 x 1.8 x 1.5 m was smeared (plastered) with mud leaving a small door and some opening close to the roof for ventilation. Sweetpotatoes were stored in layers separated by a 2 cm thick layer of *dambo* sand. A small amount of water (about 1 litre) was sprinkled to prevent dessication.

Kihenge Storage. The *kihenge* (a simple raised and roofed woven but unsmeared hut) was used. Sweetpotato roots were packed in a *Kihenge* and left for 3 months. No other treatment was applied.

Chemical analysis. This was done using AOAC(1995) official methods of analysis for moisture, crude protein, ash and fat. Vitamin C was determined by 2,6-dichlorophenol indophenol method andsugar by Lane and Eynon method. Sensory evaluation was done using a 5 point hedonic scale where 1=very poor and 5=very good. The data was subjected to Analysis of Variance and means separated by LSD (Steel and Torrie, 1980).

Results and Discussion

Changes in physical characteristics. *Dambo* sand encouraged sprouting of tubers during storage, causing significantly (P<0.05) higher number of roots sprouting. This finding confirms reports by Sandifolo *et al.* (1997), that *dambo* sand provides good media (nutrients) for growth. The *mjinge* storage method also encouraged sprouting of roots. This was due to in addition to *dambo* sand, the relatively higher moisture content that was maintained in the shelter. There were significant (P<0.05) differences in number of roots sprouted between the pit storage and *kihenge* storage treatments and no significant difference between the *kihenge* storage and *mjinge* was found. The major cause of losses was rotting and insects damage. Although sprouting was evident, it did not affect the perceived sugar content and the general acceptability of boiled roots (Table 1).

In their study, Sandifolo *et al.* (1997) had shown that storage methods (*Mjinge* storage, improved open pit storage treated with *dambo* sand and traditional pit storage) differed significantly (P<0.001) in terms of preserving quality. However, results of the present study show no significant (P>0.05) difference between *mjinge* storage and improved open pit storage treated with *dambo* sand, while the traditional pit storage and *kihenge* storage methods differed significantly (P<0.05). The *mjinge* storage method was superior in preserving the produce quality followed by the improved open pit storage treated with *dambo* sand and *kihenge* storage, respectively. The number of rotten roots was highest in the traditional pit storage. The number of clean (undamaged) sweetpotato roots was still high in *mjinge* storage and improved open pit storage treated with *dambo* sand respectively. The latter findings are in agreement with the experiment conducted by Sandifolo *et al*, (1997).

Chemical analyses. Results of chemical analyses of crude protein, fat, ash, dry matter, sugar and vitamin C are shown in Table 2. The storage methods differed significantly (P<0.05) in preserving the proteins. An increase in protein content was observed for *kihenge* stored sweetpotatoes and a slight decrease in the improved open pit treated with *dambo* sand and *mjinge* storage methods. It is likely that the reason behind the decrease in protein content with improved pit with *dambo* sand and *mjinge* storage methods was due to loss in nitrogen during storage as suggested by Bauman *et al.* (1990).

The results of this study (Table 2) show a significant (P<0.05) difference in crude fat between *kihenge* storage and the *mjinge* and

Table 1: Number of roots sprouted, rotten, wilted and weight loss after 3 months storage by different storage method.

Storage method	Number of roots showing signs of sprouting	No. of rotten roots	No. of wilty roots	Weight loss (kg)	No. of infested roots
Traditional pit storage	1.500[c]	166[a]	0.5[b]	48.0[a]	123.0[b]
Improved open pit	178.5[a]	5.5[c]	1.0[b]	13.0[c]	6.0[c]
Improved housed pit *(Mjinge)*	183.0[a]	4[c]	1.5[b]	15.5[c]	8.0[c]
Kihenge	39.0[b]	3.8[b]	5.3[a]	31.5[b]	49.5[a]

[2] Means in the same column followed by different superscript letters differ significantly (p<0.05).

Table 2: Chemical composition of sweetpotato before and after 3 months storage.

	Crude protein (%)	Ether extract (%)	Ash(%)	DryMatter (%)	Sugar (%)	Vitamin C (%)
Before storage	4.895[c]	0.874[b]	2.710[a]	91.13[b]	6.250[a]	4.005[c]
After storage						
Traditional pit storage	0.003[a]	0.017[a]	0.24[a]	3.03[a]	0.010[a]	0.001[a]
Improved open pit	4.180[b]	0.6975[b]	3.060[b]	91.940[b]	10.25[c]	1.66[b]
Improved housed pit *(Mjinge)*	4.680[b]	0.7095[b]	3.290[b]	92.410[b]	9.25[c]	1.93[b]
Kihenge	6.060[c]	0.8850[c]	3.330[b]	92.313[b]	6.50[b]	1.25[b]

[2] Means in the same column followed by different superscript letters differ significantly ($p<0.05$).

improved open pit storage treated with *dambo* sand. There was no significant difference between *mjinge* storage and pit treated with *dambo* sand. The *kihenge* storage revealed a high superiority in storage in terms of the crude fat preserved.

In this study, ash content was significantly ($P<0.05$) higher in all storage methods, except in the traditional pit storage (Table 2), which had lowest ash content compared to fresh potatoes. It was also observed that the ash content was not significantly ($P>0.05$) different between the *mjinge* and *kihenge* storage methods.

There was a significant ($P<0.05$) increase in sugar content in all methods except in the traditional pit (Table 2). These results support the work by Morrison *et al.* (1993) that during storage α- and β-amylase activities increase. Also, Lambou (1958) reported increases in sucrose, glucose and fructose contents due to hydrolysis of starch. In this study (Table 2), the amount of dry matter was not significantly ($P>0.05$) different from the fresh potato roots and the roots stored under *mjinge* and *kihenge* methods. The traditional pit resulted in highly significant ($P<0.05$) reduction in dry matter. The level of vitamin C decreased significantly ($P<0.05$) with storage (Table 2). The decrease in this vitamin could have been influenced by the change in the storage temperature, which was fluctuating during the storage period.

Acceptability of stored sweetpotato. Results of sensory evaluation are shown in Table 3. Except for the traditional pit storage method the rest of the storage methods did not significantly affect acceptability of the sweetpotatoes. Sweetpotatoes stored in traditional pit storage were heavily infested, damaged and rotten. *mjinge* storage method produced sweetpotatoes that were significantly ($P<0.05$) more acceptable. This finding confirms the claims by Mbeza *et al.* (1986) that *mjinge* is suitable in preserving sweetpotatoes and that this method can store sweetpotato for up to 8 months without spoilage. *Mjinge* treatment produced sweetpotatoes that were significantly ($P<0.05$) sweeter than the rest. The *mjinge* storage method produced the sweetest sweetpotatoes while the improved open pit treated with *dambo* sand and *kihenge* storage showed no significant ($P>0.05$) difference in sweetness when boiled. The uncooked sweetpotatoes revealed a highly significant ($P<0.05$) difference in sweetness among the storage methods. The sweetpotatoes from *mjinge* storage method were sweetest while those from *kihenge* and the traditional pit storage methods were the least sweet. There was no significant ($P > 0.05$) difference in starch levels between improved open pit storage treated with *dambo* sand, *mjinge* and *kihenge* storage methods, despite the sweetness differences observed.

Table 3: Mean scores of sensory attributes for sweetpotatoes stored by different methods[1,2]

Storage method	Sweetness		Starchy mouth-feel		Smell		Colour		General acceptability
	raw	boiled	raw	boiled	raw	boild	raw	boiled	
Traditional pit storage	2.05[a]	1.76[a]	2.44[a]	2.07[a]	2.02[a]	2.94[a]	1.88[a]	1.98[b]	2.04[a]
Improved open pit	3.34[b]	3.75[b]	3.63[b]	3.37[b]	3.67[b]	3.42[b]	3.42[b]	3.07[b]	3.22[b]
Improved housed pit *(Mjinge)*	4.00[c]	4.19[c]	3.71[b]	2.85[b]	3.45[b]	3.37[b]	3.45[b]	3.37[b]	4.14[c]
Kihenge	2.45[a]	3.48[b]	4.15[b]	3.37[b]	4.13[c]	4.15[c]	4.13[c]	4.15[c]	3.41[b]

[1]Entries are mean scores based on a 5-point hedonic scale with: 1 = very poor, 2 = poor, 3 = fair, 4 = good, 5 = very good.

[2] Means in the same column followed by different superscript letters differ significantly (p<0.05).

The smell of sweetpotatoes from the four storage methods were significantly (P<0.05) different from that of fresh sweetpotatoes. This could have been a result of infestation by insects, weevils and microbes. It is also thought to be due to continued degradation of proteins and other biologically active constituents that take place during storage. Sweetpotatoes from *kihenge* storage method had a smell close to that of fresh sweetpotato and thus most accepted. This was probably because there was little degradation of organic compounds in the sweetpotato and little infestation in this method. The sweetpotatoes underwent wilting that concentrated the soluble solids.

Sweetpotatoes store in the *kihenge* treatment were significantly (P<0.05) most appealing in colour. No significant (P>0.05) difference in colour existed between sweetpotatoes stored in improved open pit treated with *dambo* sand and those stored in *mjinge*. The sweetpotatoes stored in traditional pit were the least appealing and had unattractive colour. Sweetpotatoes from the *kihenge* storage method were not significantly (P>0.05) different in colour, compared to fresh sweetpotatoes, thus highlighting the potential of this method of storing fresh sweetpotatoes. All methods of storage resulted in significant (P<0.05) losses of vitamin C.

Conclusions

Results obtained from this study strongly suggest that *mjinge* storage method is a suitable method for storage of fresh sweetpotatoes up to three months. However, this method like the rest, results in substantial losses of vitamin C. The sprouting of roots in storage did not affect their overall acceptability and the chemical composition after storage; actually it increased the sugar content, an attribute that is preferred in the market.

Also, the *mjinge* storage method would be a suitable method, where sweetpotato roots are to be blended with cereals for composite flours to prepare different traditional food like porridges. This is because there is a tendency of an increase in sugar content of sweetpotato stored by this method.

The traditional pit storage was unsuitable for storage of sweetpotato. This confirms our field finding that most people do not store their potatoes using this method. They would rather sell their crop immediately after harvesting, even if the price is very low.

Recommendations

The storage methods investigated in this study need wider dissemination in sweetpotato growing areas. Farmers need to be taught about the potential of *dambo* sand in sweetpotato storage and its identification. Since *dambo* sand is not readily available, studies on alternative materials of similar characteristics need to be investigated. Efforts to tap the vast potential of sweetpotato in Tanzania need intensification. In the future, handling practices and manipulation of storage environments may be tried out for more effective ways to reduce moisture and nutrient losses.

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