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POST-HARVEST EVALUATION OF SELECTED SWEET POTATO VARIETIES FOR PERISHABILITY AND CONSUMER ACCEPTABILITY IN TANZANIA

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INTRODUCTION

Sweet potato (*Ipomoea batatas* (L) Lam) is an important food security crop in many countries of the world. It is a particularly suitable food security crop as it produces a high yield in a short growing season and grows well in conditions of low rainfall. In Tanzania and elsewhere the storage roots are used for human consumption. In addition to carbohydrates they are high in vitamins, especially orange-fleshed cultivars, which are particularly high in vitamin A. Sweet potato leaves are also used for human consumption as relish in many regions. In addition, both roots and foliage are used for animal feed in many countries.

Within a crop improvement programme the post harvest evaluation of the crop is very important to ensure that the varieties developed are suitable for their intended use. During surveys conducted in Tanzania, it was clear that farmers do not select their varieties on the basis of yield alone, but aslo consider post-harvest characteristics (Kapinga *et al*., 1995). The work described here is concerned with the assessment of the consumer acceptability of sweet potato varieties, and also the assessment of varieties with respect to their storability or shelf-life.

The period over which sweet potato roots need to be kept prior to consumption varies depending on cirumtances. In regions where continuous cropping is possible, very little storage is needed. However, even in these cases, part of the harvested crop is likely to be kept for at least a few days before consumption. Increasing urbanisation of population has necessitated an increase in the amount of food transported into towns for marketing (Ndunguru, 1992), which is likely to further extend the time between harvest and consumption, such that it has become more important to identify varieties with long shelf-life. In most areas, continuous cropping of sweet potato is not possible. In these cases processing of sweet potato is often practised to produce a less perishable commodity. However, as an alternative, long term storage of sweet potato is practised in some highland regions of Tanzania (Kapinga *et al*., 1995). Trials conducted in Uganda have recently indicated that long-term storage is possible even at tropical temperatures (NRI and NARO, 1996). If such a practice were to become more widespread, the identification of suitable varieties would again become very important.

The perishability of fresh sweet potato roots has been identified as a major constraint to the potential of the crop in East Africa and other tropical regions where low temperature storage is not feasible. The objective of this study was therefore to improve storability and quality of the fresh root. Although the study was focused on Tanzania, the information obtained should be of value to other regions, particularly other parts of East and Southern Africa. Sweet potato germplasm in the country is enormously diverse, providing an opportunity to improve the post-harvest characteristics by cultivar selection, both from existing cultivars, and in the longer term, by the development of new cultivars through breeding programmes. The study therefore was initiated to: increase efficiency of selection by identifying the factors associated with storability and good quality, and secondly, to develop an understanding of the influence of environmental factors, both pre- and post-harvest, so that improved production and handling practices can be defined. This report summarises the results of trials which have been carried out by the Tanzanian National Root and Tuber Crops Research Programme at five Research Institutes: Ukiriguru, Kibaha, Uyole, Tengeru and Chollima-Dakawa, during the 1994/95 and 1995/96 cropping seasons.

MATERIALS AND METHODS

The post-harvest evaluation was carried out on sweet potato roots harvested in advanced yield trials located at Kibaha, Ukiriguru, Tengeru, Uyole-Mitatula and chollima-Dakawa in the 1994/95 and 1995/96 cropping seasons. The varieties used per location and their characteristics at harvest are presented in Table 1. These were selected from the diverse germplasm that exists per location and represent varieties which are most popular in farmers fields in those locations.

The characteristics of the storage roots for each variety were noted using descriptors defined by the International Potato Centre (Human, 1992). Following harvest, only marketable roots, defined as being of marketable size and free from rots and infestation by weevils (*Cylas* sp) were selected for the post-harvest evaluation. An initial assessment of physical characteristics was carried out at this stage. Root hardness was measured using a handheld penetrometer on opposite sides of the root, after peeling the skin from a portion of the surface. The mean of the two measurements was recorded. Sugar content was calculated from the refractive index of the root sap using a handheld refractometer. The root sap was extracted by grating portions of the flesh and squeezing it in a handheld press. The selected roots for each variety were divided into two treatments. For treatment 1 roots were left undamaged, while for treatment 2; roots were damaged in an attempt to simulate effects of handling and transport during normal market practice. In 1994/95 roots were damaged by placing the roots of each variety in a sack and throwing/dragging the sack four times down a flight of steps. This method was modified in 1995/96 by placing the sacks in a metal drum and rolling the drum four times down a 100m stretch of a rough road (Rwiza *et al*., 1995). For each variety the roots from each treatment were divided into three replicates, which were placed in fertiliser bags and were stored in a room where daily temperatures were recorded. The fertiliser bags were tied closed for two days, after which they were left open. Assessments were carried out at 7 day intervals until 21 days for Ukiriguru, Chollima-Dakawa and Kibaha; and until 28 days for Tengeru and Uyole-Mitatula.

During storage the roots of each replicate were assessed for externally visible rotting using a 1-5 scale, where: 1 = no rotting;

2 = 1 - 25% rotting; 3 = 25-50% rotting; 4 = 76-100% rotting. An overall rotting score for each replicate was calculated as the mean root score, using the following formula: (1xN1+2xN2+3xN3+4xN4+5xN5)/(N1+N2+N3+N4+N5), where: N1 is the number of roots scoring 1, N2 the number of roots scoring 2, etc. Each week two roots were selected from each replicate for destructive sampling. The roots were cut longitudinally into two to assess the extent of internal rotting, using the same 1-5 sore as above. The same roots were then used to measured dry matter content. The rate of fresh weight loss was determined by selecting six roots that were weighed and marked 1-6 at the time of harvest, and were then reweighed at 7 day intervals. Consumer acceptability assessment were carried out by boiling the roots until cooked, cutting these into portions and labelling each only with a number. A panel of assessors, mainly local farmers at many sites, were asked to give scores for acceptability, taste and appearance. Data were analysed as split plot in a randomised block design.

RESULTS AND DISCUSSION

CHARACTERISTICS OF ROOTS AT HARVEST

Some physical characteristics which are likely to affect consumer acceptability, such as hardness, dry matter content and sugar content were recorded at harvest (Table 1). These varied in magnitude indicating that they may be affected by climate, soil, etc. For instance, although the same varieties were used at Kibaha and Ukiriguru, values obtained differed.

LOSS OF FRESH WEIGHT

The percentage weight loss observed at each of the five sites during storage of the sweet potato roots is shown in Figure 1. No significant differences were observed between cultivars at any station, and therefore the results are averaged over cultivars. At all sites, except at Ukiriguru, the effects of initial damage increased the rate of weight loss.

The rate of weight loss varied considerably between stations. The highest rate of loss was observed at Dakawa, followed by Kibaha and Ukiriguru. On the assumption that most of the weight loss was the result of water loss, the difference between stations is probably due to differences in both temperatures and relative humidity. Tengeru and Uyole-Mitatula, having low relative humidity and temperatures, accounted for low values of weight losses when compared to other sites.

DRY MATTER CONTENT

Changes in dry matter content during storage were measured at three of the five stations (Tables 2, 3 and 4). Dry matter content increased with time to an extent that confirmed that most of the weight loss observed was due to water loss. As previously observed, cultivars differed significantly in their dry matter content at harvest. However, no cultivar by storage time interactions were observed in any case. There were no significant differences observed between damaged and undamaged roots.

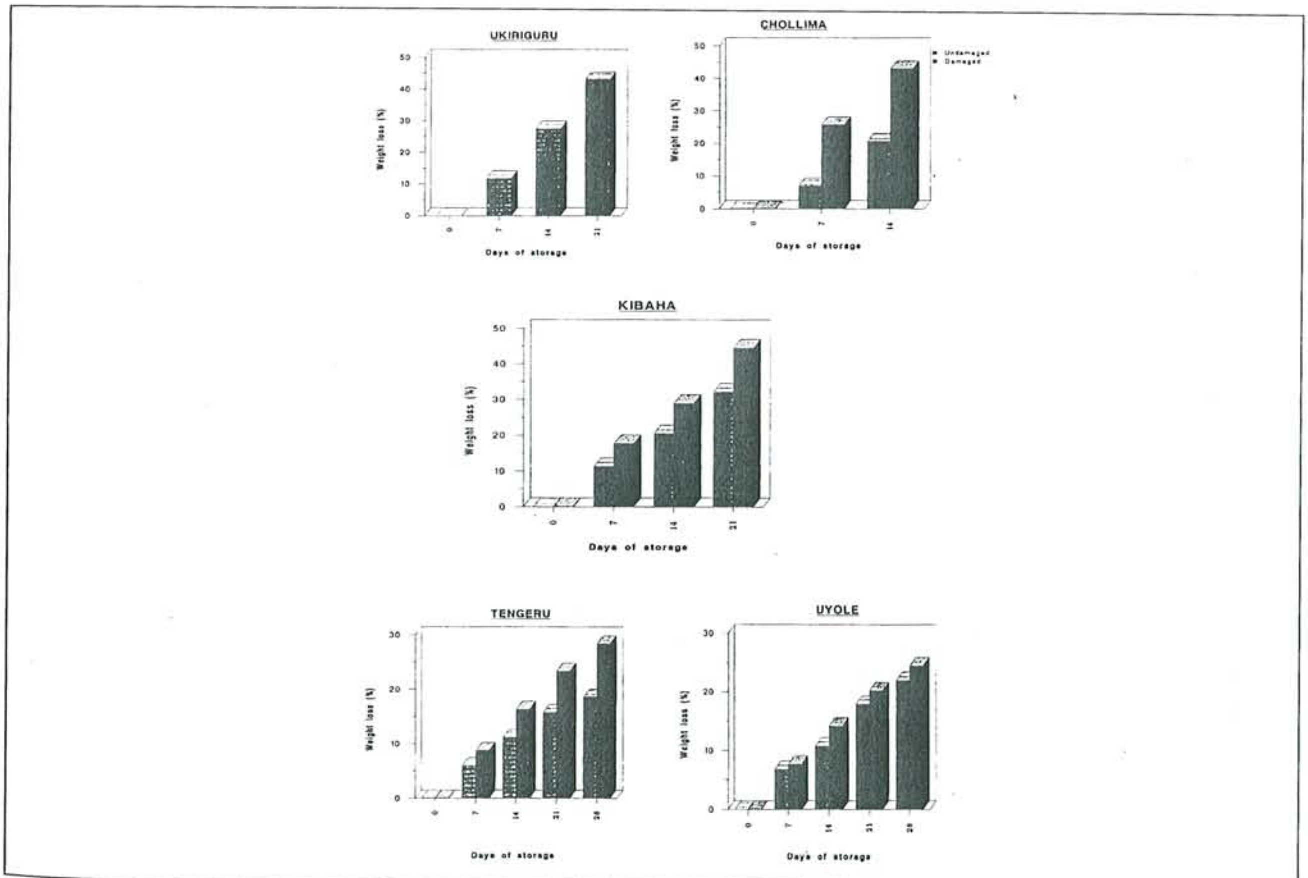

Fig 1. Percentage weight loss of fresh sweet potato as influenced by mechanical damage and storage time.

ROTTING

Unlike the rate of fresh weight loss, significant differences in the rate of rotting between cultivars were observed at all sites where rotting occurred. Figures 2 and 3 show the rate of externally observable rotting and internal rotting for each cultivar studied at Ukiriguru, Kibaha and Uyole-Mitalula. At Uyole-Mitatula, damage treatment was found to increase the rate of rotting. However, cultivar by treatment interactions were not significant, indicating that the ranking of cultivars was not affected by the damage treatment.

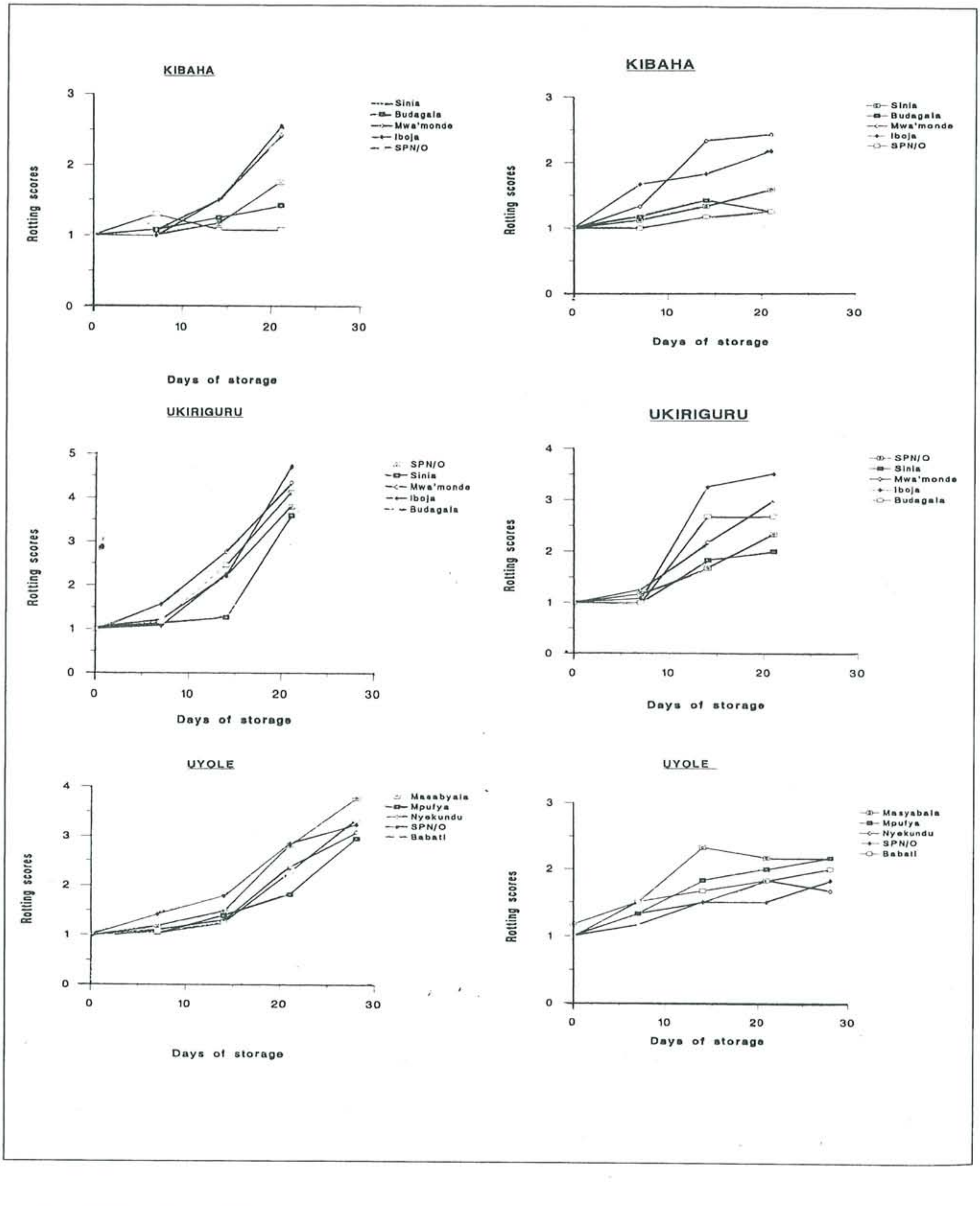

Fig 2. External rotting exhibited on fresh sweet potato roots as influenced by cultivars and storage time. Fig 3. Internal rotting exhibited on fresh sweet potato roots as influenced by cultivars and storage time.

For Ukiriguru and Kibaha, the running at 21 days after storage was essentially the same. Thus Sinia and SPN/O showed low rates of rotting, while Mwanamonde and Iboja showed the fastest rates of rotting. At Uyole-Mitalula it was also possible to identify slow rotting and fast rotting cultivars. In this case, variety SPN/O was noted as a fast rotting variety together with Masyabala, whereas Mpufya, Nyekundu and Babati tended to be slower. Data on internal rotting showed that in some cases some roots which appeared to be sound outside were rotted internally. The information obtained in this way was therefore a good backup to external observations. However, it should be noted that the extent of rotting will tend to be underestimated where rotten roots have been discarded. Despite this, internal rotting gave similar results to external observations at Ukiriguru and Kibaha, and only differed at Uyole-Mitalula by indicating that slow rotting in SPN/O is usually observable externally so that rotten roots are removed more efficiently.

ROOT FIRMNESS

The firmness of root flesh assessed during the course of the storage period showed that there were significant differences between cultivars. In the case of Ukiriguru and Kibaha these were consistent, with Iboja as the hardest variety and Budagala as the softest (Fig. 4). In all cases there were also very significant differences between storage times. At Ukiriguru the hardness of root flesh of each variety decreased with storage time for two weeks, thereafter it increased again due to substantial water loss associated with wilting, which made it impossible for the handheld penetrometer to penetrate the root flesh easily.

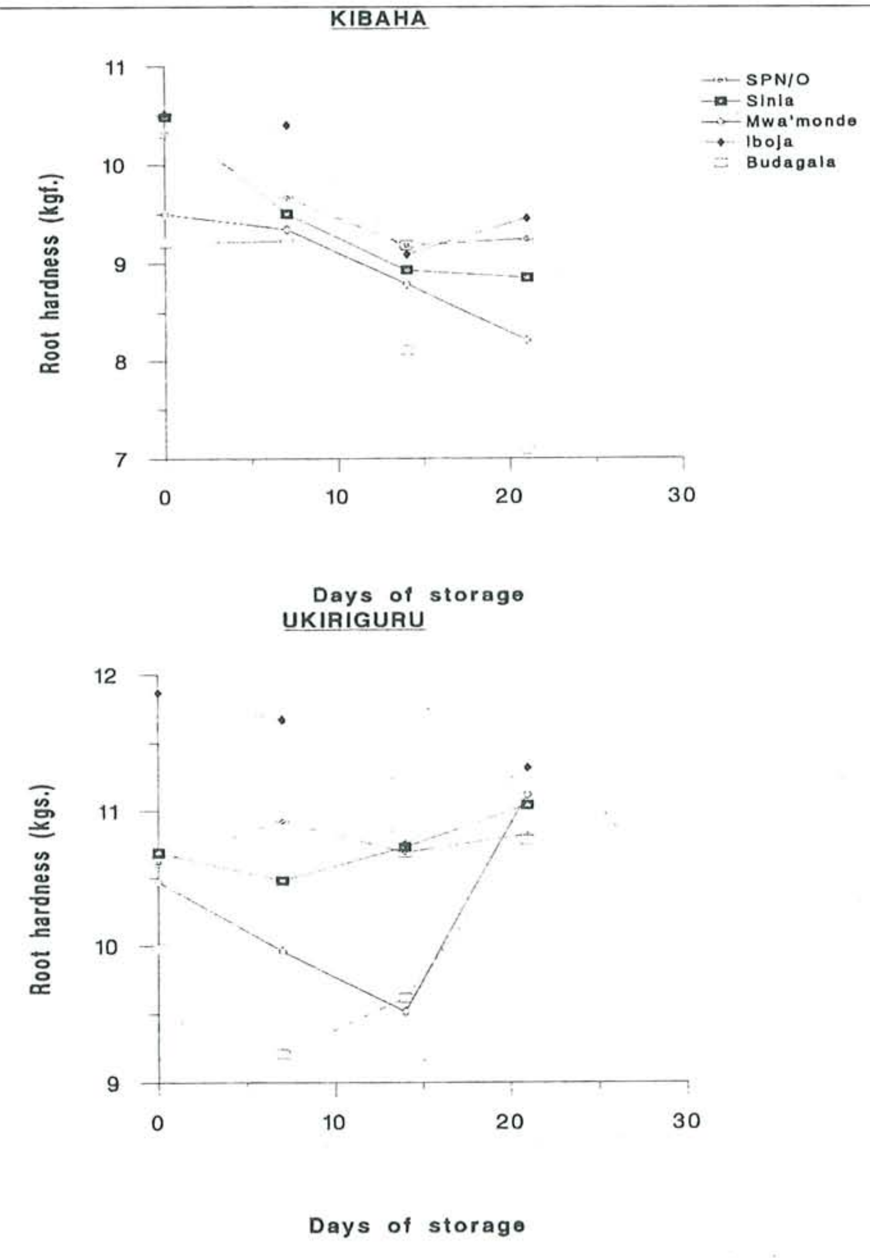

Fig 4. Changes in root firmness as influenced by sweet potato cultivars and storage time.

CONSUMER ACCEPTABILITY

Consumer acceptability of storage roots must be considered a very important criterion for varietal selection. Furthermore, a variety selected for good storability must maintain its acceptability (taste, texture and appearance), as well as being resistant to rotting and water loss.

In this study consumer acceptability was assessed very simply by asking a group of local consumers to score cooked roots of each variety for appearance, taste and overall acceptability. The consumers were not informed which variety was which, but may have been able to recognise certain familiar varieties. Assessments were carried during both seasons, but more extensively in the second. They are presented separately for four of the five stations in Tables 5 to 8.

The assessment done immediately after harvest indicate that there are distinct varietal preferences. Generally it appears that both appearance and taste of the cooked roots contribute to overall acceptability. SPN/O, which is grown in many areas of Tanzania and was included as a test variety at all sites, was the most acceptable in almost all cases. At Tengeru, however, where assessments were carried out during both seasons, SPN/O did to score well in 1995/96, although it did well in 1994/95. Interestingly, SPN/O does not grow well in the environment at Tengeru, as it does in other areas of Tanzania. Changes in the environment between sites and seasons may well affect the taste and texture of the root. In 1995/96 at Ukiriguru at 14 days of storage, roots of varieties Mwanamonde and Iboja had already been discarded because of extensive rotting, and hence were not assessed (Table 6).

At both Ukriguru and Kibaha, where the same varieties were assessed, Iboja was the least acceptable. At both locations it was observed that the roots turned blackish after cooking, giving an unpleasant appearance.

The variety Sindano at Dakawa was considered not very acceptable. Panellists complained of low dry matter content, and this was confirmed by measurements. This variety is very popular for its leaves, but the roots are also marketed, particularly for making soft meals during the fasting month.

Assessments were also carried out after storage to asses how well varieties maintained their acceptability. At most sites this was only carried out in 1995/96, but at Tengeru and Ukiriguru it was carried out during both seasons (Tables 5 and 6). It was noticeable that in each case varieties differed in the rate at which their acceptability changed, such that generally the ranking of varieties changed with time. However, this tended not to be consistent with season (at Tengeru) or between sites (comparing Ukiriguru and Kibaha). For example at Tengeru during 1994/95, Chumbageni stored very well, and was considered better than SPN/O after 4 weeks. In 1995/96, however, Chumbageni did not store so well, whereas Mafaransa performed better. Likewise at Ukiriguru in 1995/96 Sinia became the most acceptable variety after storage, far outranking SPN/O, whereas at Kibaha, SPN/O ranked the highest after storage.

GENERAL OBSERVATIONS AND FUTURE PLANS

Information generated from four different agroecological zones for two seasons indicate that:

- Although water loss is an important form of deterioration, the results presented in the report show no cultivar differences, and therefore provide no evidence that breeders could select for cultivars with good water retention qualities. So far only 16 varieties among the diverse germplasm that exist in the country were used. Therefore in future a wider range of varieties would need to be assessed to established whether or not this is the case. Handling practices and manipulation of storage environments may be more effective ways to reduce water loss during storage.

- One of the objectives of the trials reported was to try to identify root characteristics that are associated with good or bad storability. This would not only provide information about the mechanisms involved but might also facilitate the selection of cultivars with long shelf-life within breeding programmes. However, the results showed that there was no relationship between storability and dry matter content, sugar content and root hardness. There might be some weak indication that sin toughness, or cortex thickness could be related to storability. Further observation will be recorded in future.

- In addition to rotting, weight loss (primarily as a result of water loss) is a very important form of deterioration, and can be greater than 40% over two weeks of storage. The extent of rotting varied with location, and was insignificant at two sites (Tengeru and Chollima-Dakawa). In al cases there were very significant cultivar differences in the rate of rotting. For the two sites where the same cultivars were tested (Ukiruguru and Kibaha) the same ranking of cultivars was observed. This is an important result, as it indicates that results obtained at one location might also be applicable at a different location. Thus in future trials the same varieties will be tested in five locations to investigate location effects. This would have important implications in the strategy to be used in cultivar selection.

- For most of the variables assessed there was little or no variation between damaged and undamaged roots. This might be attributed to the extent of damage on the roots labelled damaged. Since the damaged roots were mainly bruised, which didn't affect the internal tissue, it is important in future to consider other types of damage such as wounding (cuts), which transfer common types of damage found in the market.

As these studies have only recently been initiated, we do not yet know whether these inconsistencies are real, or whether they are due to errors in the method of assessment. For example, it has been observed that cooking time differs between varieties, and with time of storage. Errors would be introduced wherever roots have not been cooked for the optimum time. These experiments will be repeated for two more seasons to refine the results.

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Table 1: Characteristics of sweet potato varieties assessed in four zones for post harvest qualities at harvest (1994/95 and 1995/96).

Zone (location)	Variety name	Root Characteristics					
		Storage root yield (t/ha)	Skin toughness	Cortex thickness	% Dry matter content	Sugar content (RI)	Hardness (kgf)
Lake zone (Ukiriguru)	Sinia	(12.7)	Very tough	Very thick	43.3(38.9)	12.1(8.1)	10.7(10.0)
	SPN/O	(18.2)	Very tough	Very thick	37.7(40.9)	12.5(8.4)	11.2(10.0)
	Mwanamonde	(11.6)	Interme-diate	Thin	40.4(42.0)	13.1(8.6)	10.5(10.7)
	Iboja	(11.9)	-	Thin	45.5(38.5)	11.1(7.5)	11.5(8.0)
	Budagala	(10.3)	Soft	Thick	39.9(42.7)	10.5(9.9)	10.0(9.2)
Northern zone (Tengeru)	SPN/O	(18.2)	-	Thin	32.2	10.0	8.5
	Tengeru-Red	(11.9)	-	Very thin	33.0	9.5	8.4
	Chumbageni	(11.6)	-	Very thin	35.9	9.5	8.4
	Mafaransa	(10.3)	-	Very thin	38.6	9.5	9.5
	Madiira	12.7)	-	Thin	34.1	9.5	11.3
Southern Highlands zone (Mitalula)	Masyabala	(-)	-	Thin	-	8.4(10.8)	11.4(10.0)
	Mpufya	(-)	-	Thin	-	8.4(8.9)	11.2(9.8)
	Nyekundu	(-)	-	Very thin	-	8.0(9.6)	9.9(12.0)
	SPN/O	(-)	-	Thin	-	8.6(10.3)	9.1(12.1)
	Babati	(-)	-	Thin	-	8.6(10.3)	10.7(10.7)
Eastern zone (Kibaha)	SPN/O	(8.5)	Tough	Thin	39.2(34.5)	10.0(9.3)	10.3(11.0)
	Sinia	(4.5)	Tough	Inter-mediate	44.8(37.3)	12.2(8.6)	10.5(9.3)
	Mwanamonde	(4.1)	Soft	Very thin	39.6(38.4)	11.0(8.1)	9.5(11.6)
	Iboja	(1.9)	Very tough	Thin	45.3(33.0)	7.0(8.4)	10.5(9.8)
	Budagala	(2.9)	Interme-diate	Thin	37.2(37.4)	10.8(8.2)	9.2(11.4)
Eastern zone (Chollima)	SPN/O	(6.4)	Tough	Very thin	28.2(26.8)	9.5(9.0)	-(9.0)
	Kasimama	(9.4)	Inter-mediate	Thin	32.5(26.3)	10.6(8.0)	-(8.0)
	Chanzuru	(-)	Tough	Very thin	29.3	10.5	-
	Sindano	(11.3)	-	-	(15.5)	(8.0)	(7.0)

Scores in brackets are data for 1994/95; - Not assessed.

Table 2. **Changes in dry matter content with storage time at Dakawa, Eastern zone (1995/96)**

Storage time	Dry matter content (%)			
	SPN/O	**Kasimama**	**Chanzuru**	**Mean**
0	28.2	32.5	29.3	30.0
7	49.7	53.6	52.5	52.0
14	51.4	54.2	53.4	53.0
Mean	43.1	46.8	45.0	
CV(%) = 7.2				

LSD 0.05

Variety = 2.5
Time = 2.4
Time within variety = 4.1
Variety within time = 4.2
Variety x time = ns

Table 3. **Changes in dry matter content with storage time at Kibaha, Eastern zone (1995/96)**

Storage time	Dry matter content (%)					
	Sinia	**Budagala**	**M'monde**	**Iboja**	**SPN/O**	**Mean**
0	44.8	37.2	39.6	45.3	39.0	41.2
14	51.2	43.0	48.7	52.4	43.0	47.6
21	62.0	53.0	56.9	59.4	48.4	55.9
Mean	52.7	44.4	48.4	52.4	43.5	
CV (%) =9.7	9.7					

LSD 0.05

Variety = 2.8
Time = 2.5
Time within variety = 5.5
Variety x time = ns

Table 4. Chantes in dry matter content with storage time at Tengeru, Northern Zone (1995/96)

Storage time	Dry matter content (%)					
	SPN/O	Mafaransa	Tengeru Red	Chumbageni	Madiira	Mean
0	39.9	38.6	33.0	35.9	34.1	36.3
14	34.3	38.8	34.6	37.7	35.2	36.1
28	36.2	40.2	36.3	42.3	36.6	38.3
Mean	36.8	39.2	34.6	38.6	35.3	

Table 5. **Change in consumer acceptability of cooked roots of sweet potato varieties with storage time at Tengeru (1994/95), Northern zone and 1995/96)**

Characteristics	Variety	Before storage		14 days of storage		28 days of storage	
		1994/95	1995/96	1994/95	1995/96	1994/95	1995/96
Appearance	Mafaransa	3.0	3.9	3.6	4.1	3.5	3.7
	Chumbageni	3.2	4.0	3.8	2.8	3.9	3.4
	SPN/O	3.4	3.2	3.3	3.4	2.9	4.2
	Tengeru Red	3.3	3.4	2.9	3.2	3.0	3.4
	Madiira	2.7	3.6	3.7	2.9	3.4	3.2
Taste	Mafaransa	3.6	3.6	2.8	4.0	3.5	3.7
	Chumbageni	3.8	3.6	4.0	3.4	4.0	3.6
	SPN/O	3.6	3.3	3.2	3.5	2.7	3.6
	Tengeru Red	2.8	3.4	3.5	3.0	3.5	3.6
	Madiira	2.7	2.8	3.1	3.4	3.1	4.3
Acceptability	Mafaransa	2.2	1.3	2.1	1.7	1.9	1.1
	Chumbageni	1.8	1.2	1.5	1.7	1.5	1.7
	SPN/O	1.7	1.6	1.7	1.9	2.3	1.5
	Tengeru Red	1.9	1.7	1.7	2.0	1.9	1.7
	Madiira	2.4	1.8	1.9	2.0	1.8	1.8

Rating by farmers:
Appearance, Taste: 1 = very bad; 2 = Bad; 3 = Intermediate; 4 = Goods; 5 = Very good
Acceptability 1 = highly acceptable, 2 = moderate acceptable, 3 = not acceptable

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Table 6. **Changes in consumer acceptability of cooked roots of sweet potato varieties with storage time at Ukiriguru, Lake Zone (1994/95 and 1995/96)**

Characteristics	Variety	Before storage		14 days of storage
		1994/95	1995/96	1995/96
Appearance	Mwanamonde	4.0	4.3	-
	Budagala	4.0	4.2	2.3
	SPN/O	4.7	4.2	4.4
	Sinia	4.0	3.0	4.7
	Iboja	3.5	2.9	-
Taste	Mwanamonde	4.1	4.6	-
	Budagala	3.5	4.3	2.9
	SPN/O	4.4	3.6	4.0
	Sinia	3.8	3.2	4.7
	Iboja	3.1	2.9	-
Overall acceptability	Mwanamonde	1.6	1.3	-
	Budagala	1.5	1.2	1.9
	SPN/O	1.3	1.2	1.3
	Sinia	1.9	2.0	1.0
	Iboja	2.2	2.0	-

Rating by farmers:

Appearance, Taste: 1 = very bad, 2 = bad, 3 = Intermediate, 4 = Good, 5 = Very Good
Acceptability: 1= Highly acceptable, 2 = Moderate acceptable, 3 = Not acceptable
- Not assessed

Table 7. **Changes in consumer acceptability of cooked roots of sweet potato varieties with storage time at Kibaha, Eastern zone (1995/96)**

Characteristics	Variety	Before storage	14 days after storage
		Mean score	Mean score
Appearance	Mwanamonde	3.0	2.8
	Budagala	3.3	3.1
	SPN/O	4.9	3.2
	Sinia	3.4	3.4
	Iboja	2.4	2.2
Taste	Mwanamonde	2.7	2.9
	Budagala	3.3	4.0
	SPN/O	4.8	3.2
	Sinia	3.4	4.4
	Iboja	2.4	3.1
Overall acceptability	Mwanamonde	1.9	2.0
	Budagala	1.8	1.7
	SPN/O	1.2	1.5
	Sinia	1.6	2.2
	Iboja	2.0	2.2

Rating by farmers:

Appearance, Taste: 1 = very bad, 2 = bad, 3 = intermediate 4 = Good, 5 = Very good
Acceptability: 1 = Highly acceptable, 2 = Moderate, 3 = not acceptable.

Table 8: **Changes in consumer acceptability of cooked roots of sweet potato varieties with storage time at Dakawa, Eastern Zone (1995/96)**

Characteristic	Variety	Before storage	14 days of storage
		Mean score	Mean score
Appearance	SPN/O	4.8	4.9
	Kasimama	3.2	3.0
	Chanzuru	3.1	2.8
	Sindano	2.0	1.0
Taste	SPN/O	4.3	4.7
	Kasimama	3.0	2.0
	Chanzuru	5.0	4.0
	Sindano	2.0	1.0
Acceptability	SPN/O	1.0	1.0
	Kasimama	13.0	2.0
	Chanzuru	1.0	1.7
	Sindano	3.0	3.0

Rating by farmers:

Appearance, Taste: 1 = very bad, 2 = Bad, 3 = Intermediate, 4 = Good, 5 = Very good
Acceptability: 1 = Highly acceptable, 2 = Moderate Acceptable, 3 = Not acceptable