Methods for reducing post-harvest handling losses of sweet potato (*Ipomoea batatas* (L) Lam)

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Abstract

To improve the quality of sweet potato (*Ipomoea batatas* (L) Lam) sold in East Africa, the effectiveness of packaging methods for handling and transportation and pre-harvest curing was investigated. Transporting in cardboard cartons instead of polypropylene sacks and pre-harvest curing by pruning 14 days or more before harvest improved quality by reducing skinning injury. This, however, did not improve returns to farmers because skinning injury does not influence market value. Education of traders, wholesalers and auction agents of the advantages of extended shelf life may lead to improved market value for roots with reduced skinning injury and a demand for roots transported in cardboard cartons and pre-harvest pruning. Further investigations may be required to identify packaging methods that reduce breaks and cuts.

Keywords: Sweet potato, *Ipomoea batatas*, postharvest handling, packaging, curing, Africa

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1. Introduction

Sweet potato (*Ipomoea batatas* (L) Lam) is a traditional crop for subsistence farmers in much of East Africa and it is now increasingly being marketed. Production in Africa (1998) was estimated to be nearly 7 million tonnes and is ranked, in order of importance compared to 20 other major foods, third in Uganda and Kenya and seventh in Tanzania (Anon 2000). Transportation of roots in polypropylene sacks, often weighing in excess of 100 kg, however, can account for losses market value of 13% (Tomlins *et al.* 2000) and reduce shelf life (Ndunguru *et al.* 2000).

The quality of roots transported in polypropylene sacks in Tanzania, were most affected by the height of the drop and number of drops (Ndunguru *et al.* 2000) during loading and unloading and a large number of minor impacts (Tomlins *et al.* 2000). Partitioned cardboard boxes, containing between 14 and 23 kg roots, are used for handling and transport in the USA (Estes *et al.* 1989) and for export from the Caribbean (Medlicott, 1990).

Underground storage organs such as sweet potato roots tend to have poorly developed cuticles. Curing is recommended so that a surface layer of protective suberised wound periderm tissue is formed, especially at wound sites (Wills *et al.* 1998). Pre-harvest curing of the roots (Bonte and Wright, 1993), by removal of the plant stem and canopy up to 14 days before harvest, has been reported to reduce the injury to roots during handling and transport by 62%.

This purpose of this study was to determine if simple low-cost methods (alternative packaging technologies and using pre-harvest curing) could be developed that might be used to improve quality and market value of sweet potato. The effect on quality of four methods of packaging was compared by transporting them varying distances and pre-harvest curing by comparing roots from pruned (left in the ground for different times) and unpruned plants.

2. Materials and Methods

Experiments were in duplicate unless stated otherwise. Sweet potato roots (SPN/O cultivar) were purchased from farmers near Dar es Salaam, Tanzania.

2.1. Quality evaluation of sweet potatoes

Samples of 40 sweet potato roots were randomly collected during harvest or selected following packaging, transport or pre-harvest curing trials. They were scored for breaks, cuts, skinning injury, shrivelling, rots and weevil (*Blosyrus* and *Cylas* spp.) damage using a simple visual scoring system (Tomlins *et al.* 2000).

2.2. *Effect of packaging method on root quality*

Woven polypropylene sacks filled with either 20 or 100 kg sweet potatoes, wooden boxes (height 36 cm, length 60 cm, width 36 cm) lined with cardboard containing 30 kg sweet potatoes and cardboard boxes (height 33 cm, length 44 cm, width 30 cm) containing 20 kg sweet potatoes were compared. An impact logger (Tomlins *et al.* 2000) was positioned at the centre of each package to monitor the handling during transport.

The packages were transported together for distances of 24 km, 98 km or 167 km by light commercial vehicle from the farm to a market (Tandale) in Dar es Salaam where the roots were assessed for quality and sold at the local auction.

2.3. *Effect of pre-harvest pruning on root quality at harvest and after handling.*

Rows of sweet potatoes plants were either left untouched or had the stem and leaf canopy pruned 9, 14 or 18 days prior to harvest. At harvest, both pruned and un-pruned roots were lifted at the same time.

The effect of pruning treatment on susceptibility to damage during handling was assessed by dropping duplicate woven polypropylene sacks, containing 50 kg sweet potatoes, three times from a height of 0.5 m. The root quality was assessed for breaks, skinning injury and cuts.

2.4. *Statistical analysis*

Analysis of variance (ANOVA) was carried out using SPSS (version 8.0) statistical software.

3. Results and Discussion

3.1. Effect of packaging method on root quality

The distance that the packages were transported had no significant effect on quality and so the results were pooled (Table 1). The method of packaging influenced skinning injury ($P > 0.001$) but did not reduce the occurrence of breaks, cuts or rots. Skinning injury was reduced when roots were transported in cardboard boxes and the greatest when transported in polypropylene sacks (20 or 100 kg).

The impact histories for each method of packaging (Figures 1 to 4) show that they were on the road for the first 9 hours, stored overnight storage and at 18 to 21 hours off-loaded at the market. The impacts were greater for roots transported in sacks compared to the cardboard box and wooden crate. The number of minor impacts (less than 2 g) was greatest for roots transported in the cardboard box (Table 2). For impacts greater than 2 g, their occurrence was greater for the cardboard box and wooden crate and least in the polypropylene sacks. While the number of impacts greater than 2 g was lowest for the sacks, the occurrence of skinning injury was the highest. It is thought that tightly packing roots in polypropylene sacks caused the surface of the roots to absorb the impact energy whereas in loosely filled cartons, the roots were able to move and dissipate the energy.

At auction, the roots transported in the sacks and cardboard box fetched the same price (80 Tanzanian Shillings per kg) regardless of the distance travelled. Those transported in the wooden crate fetched a lower price (67 Tanzanian Shillings per kg). The auction agent and traders commented that the roots in the cardboard cartons were of good quality while those in the woven polypropylene sacks containing either 20 or 100 kg were of acceptable quality. Roots transported in the wooden crates were mainly of good quality but some roots were cut when they were pressed against the side of the box. The failure of roots transported in cardboard cartons to fetch a higher price might be because skinning injury does not affect market value (Ndunguru *et al.* 1998).

Further investigations are required to identify methods of packaging that reduce breaks and cuts. While transporting in cardboard boxes did not improve the market value, a reduction in the skinning injury would increase shelf life (Ndunguru *et al.* 2000).

3.2. Effect of pre-harvest pruning on root quality at harvest and after handling

Pruning the canopy up to 18 days before harvest ($P < 0.05$) reduced the skinning injury of freshly harvest roots and in roots that had been packed into sacks and dropped (Tables 3 and 4). Pre-harvest pruning did not reduce the occurrence of broken, shrivelled or cut roots and weevil infestation.

Bonte and Wright (1993) reported that the optimal pre-harvest pruning treatment was 10 days before harvest (Beauregard and Jewel cultivars grown in

Louisiana, USA). Roots began to sprout if the pruning treatment occurred at 15 days. In this study, the optimal pre-harvest pruning was greater than 10 days and roots did not. These different findings may be because of the different cultivar (SPN/0) and climatic conditions.

Little has been reported on the influence of pre-harvest curing on the changes in morphological characteristics, such as skin thickness, cell size and suberin content, that occur in sweet potatoes. For other root crops, such as the Irish potato (*Solanum tuberosum*), pre-harvest pruning (haulm destruction) increased skin adhesion but the magnitude differed with variety (Bowen *et al*. 1996). Changes in morphological characteristics do not appear to influence skin adhesion strength. It is speculated that changes in water content and in the biochemistry (pectins) are more important for Irish potatoes (Muir and Bowen 1994).

While reduced skinning injury is unlikely to increase the market value (Ndunguru *et al*. 1998), it may, however, extend the shelf life (Ndunguru *et al*. 2000).

4. Conclusion

Cardboard boxes filled with 20 kg of sweet potato and pre-harvest pruning of 14 days or more improved quality by reducing skinning injury. This did not lead to improved market value at auction because traders do not consider roots with skinning injury to be unacceptable (Ndunguru *et al*. 1998) and the presentation in cardboard boxes was new to them. An advantage of roots with reduced skinning injury is an extended shelf life (Ndunguru *et al*. 2000) but traders are unaware of this. Education of traders, wholesalers and auction agents of the advantages of extended shelf life may lead to improve market value for roots with reduced skinning injury and a demand for roots transported in cardboard cartons and pre-harvest pruning. Further investigations may be required to identify packaging methods that reduce breaks and cuts.

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References

Anon., 1999. CIP Sweetpotato Facts: A compendium of key figures and analysis for 33 important sweetpotato-producing countries – Production, Utilisation, Consumption, Feed Use. International Potato Center, Lima, Peru.

Bonte, D.R., Wright, M.E., 1993. Image analysis quantifies reduction in sweet potato skinning injury by pre-harvest canopy removal. HortScience 28, 1201.

Bowen, S.A., Muir, A.Y., Dewar, C.T., 1996. Investigations into skin strength in potatoes: factors affecting skin adhesion strength. Potato Research. 39, 313-321.

Estes, E., Wilson, L.G., Bandele, O., 1989. A performance evaluation of five sweetpotato shipping containers. Journal Food Distribution Research 20, 29-38.

Medlicott, A.P., 1990. Product specifications and post-harvest handling for fruits, vegetable and root crops exported from the Caribbean, Fintrac Technical Services, Birmingham, Fintrac Technical Services, Birmingham, UK, pp77-82.

Muir, A.Y., Bowen, S.A., 1994. Measuring of the adhesion strengths of potato skin related to haulm treatments. International Agrophysics 8, 531-536.

Ndunguru, G.T., Thomson, M., Waida, R., Rwiza, E., Westby, A., 1998. Methods for examining the relationship between quality characteristics and economic value of marketed fresh sweet potato. Tropical Agriculture (Trinidad) 75, 129-133.

Ndunguru, G.T., Tomlins, K.I., Rwiza, E., Westby, A., 2000. Influence of post-harvest handling on the quality and shelf life of sweet potatoes in Tanzania, Sci. Hort. [submitted].

Tomlins, K.I., Ndunguru, G.T., Rwiza, E., Westby, A., 2000. Post-harvest handling, transport and quality of sweet potato in Tanzania, Journal of Horticultural Science and Biotechnology, [accepted for publication and will be in print Sept 00].

Wills, R., Mcglasson, B., Graham, D., Joyce, D., 1998. Postharvest: An introduction to the physiology and handling of fruit, vegetables and ornamentals, CAB International, Oxon, UK (ISNN 0 85199 264 1), pp26.

Table 1. Effect of packaging materials on root quality after handling and transport.

	Root quality (total score)				
	Fresh roots	**Cardboard box (20 kg)**	**Wooden box (30 kg)**	**Polypropylene sack (20 kg)**	**Polypropylene sack (100 kg)**
Skinning injury*	6 ± 1.2	12 ± 2.0	19 ± 4.4	38 ± 5.0	43 ± 5.4
Broken roots	3 ± 1.0	2 ± 0.4	2 ± 0.2	4 ± 1.2	5 ± 1.1
Cut roots	7 ± 1.4	7 ± 1.5	5 ± 0.9	6 ± 1.1	7 ± 0.6
Rots	2 ± 0.5	2 ± 0.6	1 ± 0.6	2 ± 0.3	2 ± 0.6

**Significantly different ($P < 0.05$). Values represent the mean ±S.E.*

Table 2. Mean number of impacts for the different types of packaging.

Intensity	Mean number of impacts			
	Cardboard box (20kg)	Wooden crate (30kg)	Polypropylene sack (100kg)	Polypropylene sack (20kg)
0.2 to 2 g	546	454	493	414
2 to 5 g	29	35	4	6
5 to 10 g	6	6	1	2
10 to 20 g	1	0	0	0

Where: mean values are pooled for packages transported 24, 98 or 167 km.

Table 3. Effect of pre-harvest pruning on skinning injury when harvesting sweet potato roots.

	Skinning injury (total score)		
	9 days	**14 days**	**18 days**
Pruned	9 ± 3.55	5 ± 3.55	7 ± 3.55
Not pruned	7 ± 3.55	28 ± 3.55	21 ± 3.55

Significantly different ($P < 0.05$). Values represent the mean ±S.E.

Table 4. Effect of pre-harvest pruning o skinning injury when polypropylene sacks, containing 50 kg sweet potatoes, were dropped from a height of 0.5 m.

	Skinning injury (total score)		
	9 days	**14 days**	**18 days**
Pruned	69 ± 4.35	30 ± 4.35	40 ± 4.35
Not pruned	48 ± 4.35	78 ± 4.35	79 ± 4.35

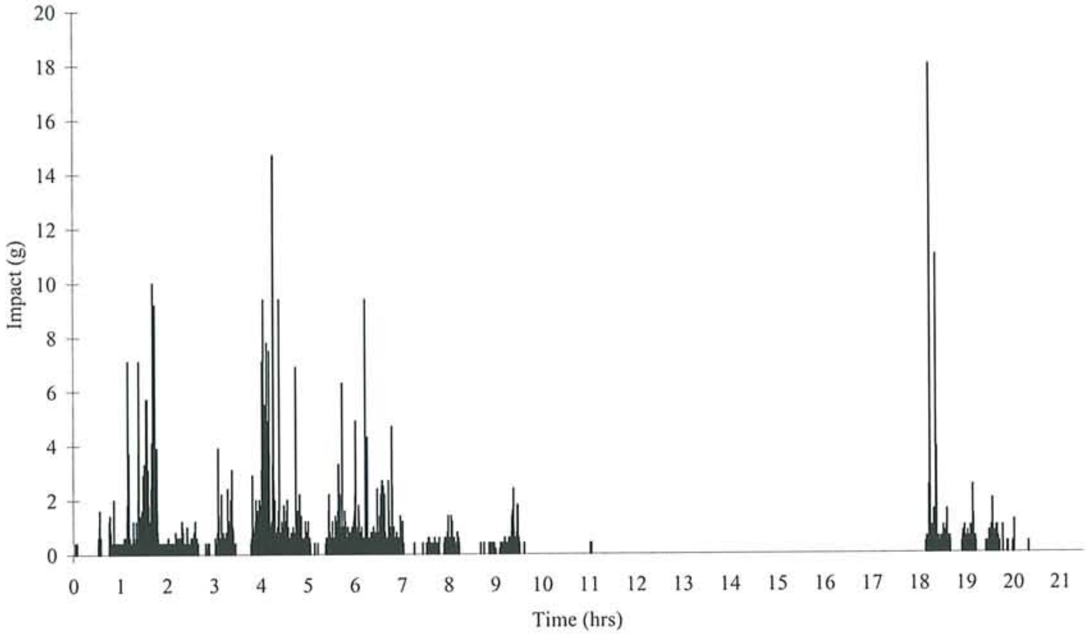
Significantly different ($P < 0.05$). Values represent the mean ±S.E.

Figure 1. Impact chart for 20 kg sweet potatoes transported 169 km in a cardboard box

Figure 2. Impact chart for 30 kg sweet potatoes transported 169 km in a wooden crate

Figure 3. Impact chart for 20 kg sweet potatoes transported 169 km in a polypropylene sack (tightly packed)

Figure 4. Impact chart for 100 kg sweet potatoes transported 169 km in a polypropylene sack (tightly packed)



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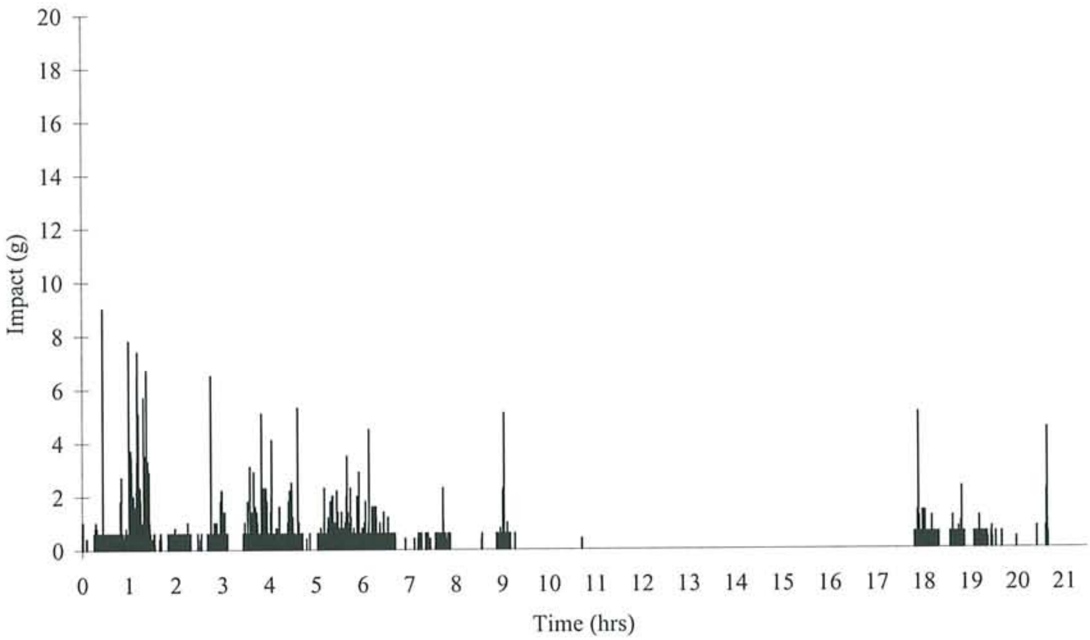

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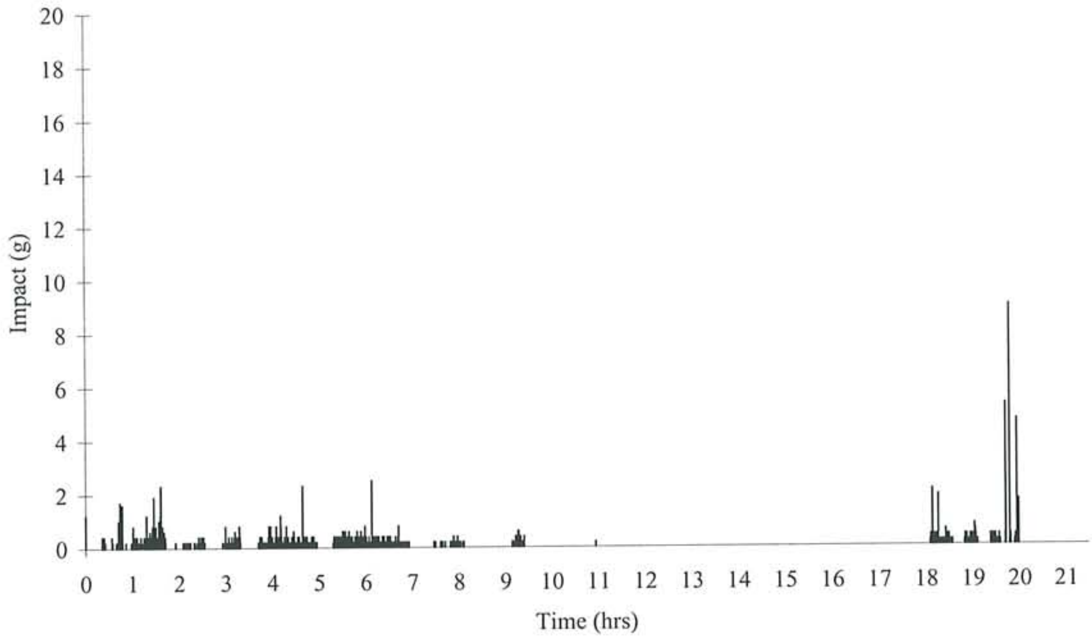

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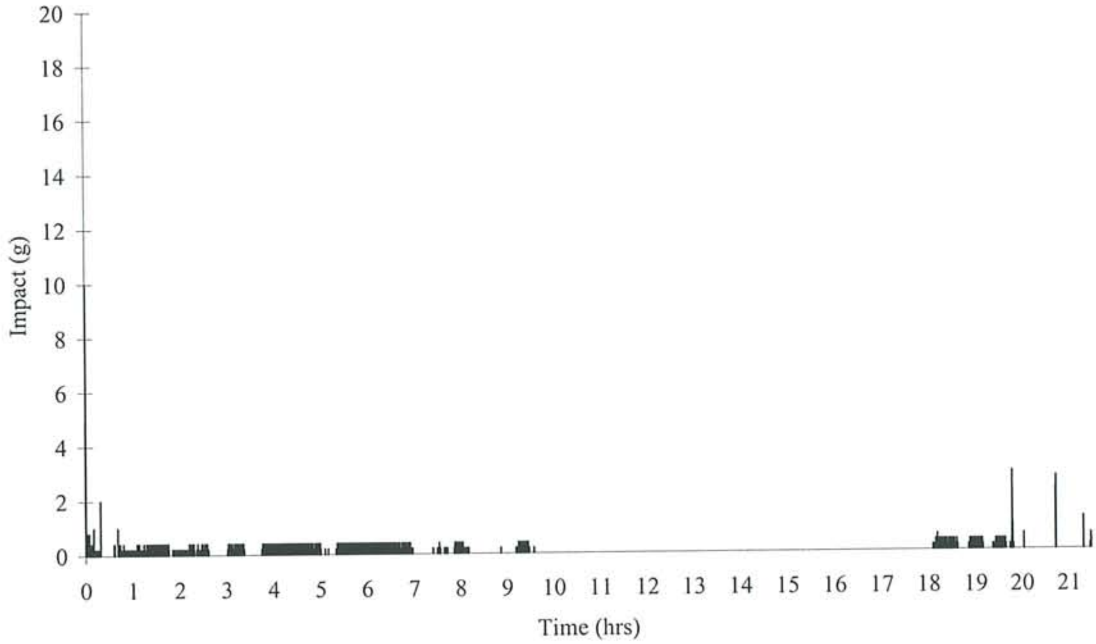
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