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Application of a Low-Cost Storage Technique for Fresh Cassava (*Manihot esculenta*) Roots in Ghana

Utilisation d'une technique de stockage bon marché pour les racines de manioc fraîchement récoltées au Ghana

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- Abstract -

A series of experimental on-farm storage trials was carried out in Ghana to determine whether the application of water or fungicide (thiobendazole) to freshly harvested cassava roots prior to or during storage in either polyethylene bags or recycled rice sacks (woven polyethylene) could prolong the storage life of the produce. Results indicate that, if applied early enough, under ambient conditions the surroundings engendered by these treatments were sufficient to prolong the storage life of the roots from 3-5 days to 2-3 weeks. Water treatments alone in combination with either bags or sacks helped maintain the storage potential of the cassava for at least 7 days provided that microbial infection was avoided. Thiobendazole was found to not only suppress fungal rots but also enhanced the storability of the roots to an even greater extent than water alone.

- Résumé -

Une série d'essais expérimentaux a été menée dans des fermes au Ghana afin de déterminer si l'application, avant ou pendant le stockage, d'eau ou de fongicide (thiobadenzole) à des racines fraîchement récoltées contenues dans des sacs en polyéthylène ou dans des sacs de riz recyclés (polyéthylène tissé) pouvait prolonger leur durée de stockage.

Les résultats indiquent que s'ils sont appliqués suffisamment tôt, tous ces traitements créent des environnements capables de prolonger la durée de stockage des racines de 3 à 5 jours jusqu'à 2 à 3 semaines. Les traitements utilisant seulement de l'eau dans des sacs en polyéthylène ou recyclés peuvent prolonger les possibilités de stockage d'au moins 7 jours à condition que la contamination microbienne soit évitée. Il a été démontré que le thiobadenzole non seulement empêche le pourrissement microbien mais prolonge aussi l'aptitude au stockage des racines de la même manière que le traitement à l'eau.

Introduction

The characteristics of cassava (*Manihot esculenta Crantz.*) that have lead to its extensive cultivation particularly in Central and South America, South East Asia and Africa are; its relative ease of vegetative propagation, its low maintenance demands following establishment, its drought tolerance and its ability to produce yields over an extended harvesting period even on nutrient poor, marginalised soils without recourse to chemical inputs (Kay, 1987).

Set against these attributes is the extreme perishability of the fresh roots following harvest. In the absence of an infrastructure that may support refrigeration or waxing of roots, fresh produce will begin to deteriorate within 3 to 5 days (Rickard, 1985). Working within these constraints many communities have developed marketing and processing strategies to either rapidly disperse fresh cassava roots to consumers or to convert them into dry stable products amenable to storage and subsequent transportation and distribution (NRI, 1992).

The traditional systems of handling cassava have served communities well, however, with changes in lifestyles and increasing urbanisation, it will become increasingly difficult for traders to ensure the delivery of high quality fresh cassava roots to commercial or domestic clients at a distance from areas of production. A cheap and robust system capable of delaying the onset of post-harvest deterioration in cassava roots would not only increase the flexibility of the marketing systems but also reduce wastage.

In the 1980's scientists from the Centro Internacional de Agricultura Tropical (CIAT) and the Natural Resources Institute (NRI) developed and promulgated a relatively simple low-cost fresh cassava storage technique in Colombia and other states in Latin America (CIAT, 1992).

The system is based on the timely storage of high quality, fresh cassava roots in polyethylene bags combined with the application of the fungicide; thiobendazole (available as TECTO). The warm, moist environment engendered by cassava roots held in polyethylene bags under moderate ambient conditions in the tropics stimulates a curing and wound-healing response in freshly harvested roots that enhances the storage potential of the material by decreasing the rate of natural physiological deterioration. The use of the fungicide markedly reduces the frequency of deleterious fungal infections that might otherwise impair the quality of stored roots. When adopted successfully the storage life of cassava roots may be extended from 3 - 4 days to 2 - 3 weeks (Ciat, 1989).

In this paper, findings of on-farm storage trials are reported, which form part of a work programme designed to evaluate the suitability of cassava shelf life extension technology for use in Ghana (Rickard *et al.*, 1992).

Materials and Methods

Over a 3-month period, during the summer rains of 1993, factorial experiments were conducted in the Asanti Region of Ghana. These storage trials were undertaken at one village location and were designed to assess the response of locally popular cassava cultivars to different interpretations of the low-cost storage methodology. Routinely cassava was harvested from sites established on forest soils and then, after treatment, the roots were stored in dark, well ventilated but enclosed rooms with concrete walls and floors surmounted by corrugated iron roofs.

At harvest considerable care was taken to avoid damage to the roots and, in accordance with the protocols advocated by CIAT, only particular categories were selected for storage (CIAT, 1989). Those exhibiting superficial wounds could be conserved provided any damaged tissues could be trimmed away leaving a clean cut surface. Roots that were crushed, bruised or split or showed signs of gashes or invasive wounds especially at the stem end were not used in the storage trials.

Depending on experimental design (Table 1), different consignments of cassava were subjected to contrasting wash treatments. Some were kept dry, some were washed in clean water and others were treated with 0.4% thiobendazole (20 ml dispersed in 5 l water). Both water and the fungicide were applied either as a spray (to surface saturation), using an agricultural knap-sack sprayer, or as a momentary dip (30 to 60 seconds). The duration when such treatments were administered also varied. In all the trials certain washes were applied to the cassava as soon as possible after harvest while in Trials 2 and 3 particular dipping and spraying treatments were delayed for 24 or 48 hours.

Prior to storage groups of treated roots were allocated to either open-weave string sacks (composed of man-made-fibres), polyethylene bags (0.13 mm thick) or recycled rice or flour sacks composed of tightly woven polyethylene threads. The dimensions of the various bags and sacks were approximately 50-56 x 80-90 cm. In all cases the necks of these sacks were securely tied before storage. During storage the different sampling units were randomly stacked in hollow column-like configurations to encourage the relatively uniform circulation of air throughout the produce.

In Trial 2 certain consignments of cassava were placed in polyethylene bags after 24 hours in the string sacks while in Trial 4 a quantity of cassava was de-bagged from polyethylene into string sacks 4 days after treatment.

At harvest and at specified intervals during storage (Table 1), samples of roots were recovered from the various consignments and scored for their physiological and micro-biological condition. The sampling units used in the stores each consisted of 6 (Trials 1 to 4) or 7 (Trials 5 and 6) randomly selected

Table 1

Experimental methodologies adopted to investigate the influence of different storages containers and wash treatments on the extent of micro-biological and physiological deterioration of fresh cassava roots

Trial No.	Cultivars				Assessment Days				Factorial Treatments								Comments
									Containers (bags or sacks)			Washes			Application		
	Atobiase	Dabo	Fanti	Fufua	Harvest	Week 1	Week 2	Week 3	Open-Weave	Polyethylene	Recycled Rice	Dry (unwashed)	Water	Thiobendazole	Dip (d)	Spray (s)	
1	-	1	1	1	0	7	13	-	1	1	-	1	1 (d)	1 (d or s)	1	1	Application of all treatments within 6 h of harvest
2	1	1	1	-	0	8	15	-	1 (i)	1 (i or ii)	-	1	1 (d)	1 (d)	1 (i or ii)	-	Application of wash treatments and bagging within either (i) 1 h of harvest or (ii) after 24 h
3	1	1	1	-	0	7	13	-	1 (i)	1 (i)	-	1	1 (s)	1 (s)	-	1 (i , ii or iii)	Bags applied on day 0. Sprays applied on (i) day 0, (ii) day 1 or (iii) day 2
4	1	1	1	-	0	7	14	-	1	1 (i or ii)	-	-	1 (d)	1 (d)	1	-	Wash treatments applied on day 0. (i) Polyethylene bags applied after harvest and retained throughout or (ii) bags removed 4 days after harvest
5	1	1	1	-	0	6	12	18	-	1	1	-	1 (d)	1 (d)	1	-	Wash treatments and bags applied immediately after harvest
6	1	1	1	-	0	7	13	-	-	1	1	1	1 (d)	1 (d)	1	-	Wash treatments and bags applied immediately after harvest

cassava roots held together in one or other of the sack treatments. When data were collected, the contents of 3 replicate sacks were destructively assessed for each of the particular factorial treatment combinations of interest.

The effect of the experimental treatments on the quality of the stored cassava was determined by dissecting the roots and allocating scores to the level of apparent physiological and micro-biological deterioration found within.

Routinely, the contents of each sampling unit was removed and the roots ranked in order of length. The longest and shortest roots were discarded in Trials 1 to 4 while in Trials 5 and 6, every other root was de-selected. Each of the 4 remaining roots were then cut into 4 segments of equal length. Finally, each of the two end quarters were cut in half. In this manner the roots were dissected into 6 segments. Once exposed, the cross-sectional surface of each of the 5 cuts was scored on a scale 1 to 5 for the degree of microbial spoilage. In Trials 1 to 3, the physiological deterioration of the root cortex was also scored on a scale 1 to 5. In Trials 4 to 6, however, the physiological scale was extended to 6. The mean scores derived from each sampling unit were used in subsequent statistical analysis.

A microbial score of 1 suggested the complete absence of any symptoms of rot. A score of 2 implied 1-25% of the cross-sectional area of the root affected by microbial spoilage. The scores 3 to 5 donoted the increased incidence of rot from 26-50, 51-75 and 76-100% of the cut surface respectively.

Physiological scores of 1 indicated a blemish-free white cortex. A score of 2 referred to tissues exhibiting a slight cream colouration but still without signs of overt deterioration. A score of 3 described a distinct blue tinge in the tissues indicative of the onset of physiological deterioration. The scores 4 to 5 (Trials 1 to 3) and 4 to 6 (Trials 4 to 6) defined progressively more intense blue and blue/black discolourations.

Results and Discussion

The principle findings of the investigations are summarised in Tables 2 and 3. All the main experimental factors were shown to have some influence on the physiological and micro-biological status of the stored cassava roots. Although the response of the local cultivars to particular treatment combinations differed in detail, the predominant trends were the same for all the varieties studied.

Without exception, when compared to roots held in open-weave sacks, the use of polyethylene bags or recycled rice sacks greatly ($P<0.001$) retarded the onset of deteriration and the subsequent rate of spread of both physiological and microbial deterioration. Further, as exemplified in Trial 1, 4 and 6, this disparity of response was significantly accentuated over time ($P<0.05$).

Results of Trial 2 indicate that cassava placed in bags immediately after harvest maintained their quality into the third week of storage. A delay in the use of polyethylene bags by 24 h resulted in higher levels of microbial rot. This disparity was not obvious after 8 days in store but became significant ($P<0.05$) after 15 days. The level of physiological deterioration in such roots also increased.

Additional studies suggested that provided roots are allowed to 'cure' in warm, humid conditions for a period of 4 days immediately after harvest, they can then be removed and held under ambient conditions for at least a further 10 days without a significant loss of quality (Trial 4).

The manner in which fresh cassava responded to various wash treatments indicated that the water and thiobendazole dips or sprays profoundly enhanced the storage life of the roots. Moreover, the application of thiobendazole not only had the desired effect of depressing the rate of microbial deterioration, in all trials, but also could often retard the symptoms of physiological deterioration to a greater extent than water treatments alone ($P<0.001$, Trial 1).

Water treatments suppressed symptoms of post-harvest deterioration relatively efficiently for period of about a week (Trials 5 and 6). Thereafter, although physiological scores may remain acceptably low, the incidence of microbial spoilage tended to rise in comparison to thiobendazole treated roots ($P<0.001$, Trials 1 and 5). Provided cassava roots are placed in polyethylene bags soon after harvest, the efficacy of either water or thiobendazole treatments is not influenced by the mode of application or a delay of such applications for up to 2 days (Trials 1 and 3).

In practical terms both domestic and commercial consumers of fresh cassava in Ghana are likely to find produce with a physiological score of 2.5 and below and a microbial score of 1 or 2 to be quite acceptable. Using these values for guidance it is evident that most of the technical interventions studied in Trials 1 to 6 could conserve locally produced cassava at an acceptable level of quality for periods in excess of 12 to 13 days, a week longer than traditional West African systems.

Work is continuing in Ghana to adapt the storage technology more closely to the needs of various client groups and, in particular, to investigate further the potential use of recycled rice sacks as an alternative to polyethylene bags. Studies are also underway to assess the cost effectiveness of implementing such technologies under local conditions.

Table 2

The influence of different factorial treatments on the extent of micro-biological and physiological deterioration of fresh cassava roots held in store (Part 1).

Trial No.	Variables	Factorial Treatments: Main Effects	Assessment Day	Containers & Wash Treatment, Contrast Codes: 1	2	3	4	5	6	7	Contrasts (between levels)	Standard Error
		Containers	Levels	OW	P							
1	Phys.			4,50	2,20						All	0,67
	Micro.			3,60	1,90						All	0,65
		Washes	Levels	D	W (d)	T (d)	T (s)					
	Phys.			4,90	3,70	1,60	2,00				All	0,63
	Micro.		7	2,90	1,70	1,20	1,40				All	0,68
			13	4,30	3,50	1,80	1,20					
		Containers	Levels	OW	P (i)	P (ii)						
2	Phys.			3,40	2,00	2,30					All	0,33
											2 v 3	0,27
	Micro.		8	2,70	1,50	1,70					All	0,70
			15	3,50	1,40	2,30					2 v 3	0,57
		Washes	Levels	D	W (d)	T (d)						
	Phys.			3,70	2,40	2,00					All	0,32
											2 v 3	0,26
	Micro.			3,10	2,00	1,40					All	0,41
											2 v 3	0,33
		Containers	Levels	OW	P							
3	Phys.			4,00	2,40						All	0,36
	Micro.			3,20	1,90						All	0,36
		Washes	Levels	D	T (i)	W (i)	T (ii)	W (ii)	T (iii)	W (iii)		
	Phys.			4,00	2,40	2,50	2,00	2,50	2,30	2,50	All	0,55
	Micro.			3,20	2,00	2,00	1,60	2,00	1,70	1,90	All	0,56
		Containers	Levels	OW	P (a)	P (b)						
4	Phys.		7	3,30	2,10	2,10					1 v (2&3)	0,58
			14	4,50	2,40	2,50					2 v 3	0,47
	Micro.		7	2,40	1,70	1,60					1 v (2&3)	0,60
			14	3,80	2,00	2,00					2 v 3	0,49
		Washes	Levels	D	T (d)	W (d)						
	Phys.		7	3,30	2,10	2,20					1 v (2&3)	0,42
			14	4,50	2,20	2,70					2 v 3	0,34
	Micro.		7	2,40	1,60	1,70					1 v (2&3)	0,59
			14	3,80	1,80	2,20					2 v 3	0,48

Notes:
OW Open-Weave sacking — T (s) Thiobendazole spray
P Polyethylene bags — P (i or ii) Polyethylene bags applied on days 0 or 1
D Dry roots — T (i, ii or iii) Thiobendazole spray applied on days 0, 1 or 2
W (d) Water dip — W (i, ii or iii) Water spray applied on days 0, 1 or 2
T (d) Thiobendazole dip — P (a&b) Polyethylene bags retained or removed on day 4

Table 3

The influence of different factorial treatments on the extent of micro-biological and physiological deterioration of fresh cassava roots held in store (Part 2).

	Variables	Factorial Treatments								Contrasts	Standard Error
Trial No.		Main Effects	Assessment	Day	Containers & Wash Treatment					(between levels)	
		Containers	Levels		P		R				
		Washes			W (d)	T (d)	W (d)	T (d)			
5	Phys.		6		2,10	2,10	2,20	2,00		All	0,73
			12		2,60	2,30	2,90	2,20			
			18		3,40	2,20	2,60	2,60			
			Levels		W (d)	T (d)					
	Micro.		6		1,70	1,50				All	0,66
			12		2,40	1,60					
			18		2,80	1,70					
		Washes	Levels		D	W (d)	T (d)				
6	Phys.		7		2,20	2,20	2,10			All	0,27
			13		2,70	2,20	2,10				
	Micro.		7		1,60	1,50	1,40			All	0,41
			13		2,30	1,60	1,50				
Notes:	P	Polyethylene bags			D	Dry roots					
	R	Recycled Rice Sacks			W (d)	Water dip					
					T (d)	Thiobendazole dip					

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