New developments in cassava storage

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Abstract

Cassava roots deteriorate rapidly after harvest. Deterioration is either physiological or microbial, but the former generally occurs within 48 h of harvesting. Experimental results show that physiological deterioration can be prevented either by pruning the plants 2-3 wk before harvest or by packing the roots in polyethylene-lined paper bags after harvest. Microbial deterioration can be prevented by dip-treating the roots with broad-spectrum fungicides such as Manzate.

Introduction

The cassava root is highly perishable, often showing cortical necrosis (physiological deterioration) as rapidly as 24 hours after harvest; five to seven days later, microbial rotting occurs (1).

Some progress has been made in searching for varietal resistance to both types of deterioration (Kawano, personal communication); nevertheless, resistance to physiological deterioration appears to be positively correlated with moisture content (4; Kawano, personal communication). Although this correlation is not particularly close, it does suggest that it may be difficult to breed for high dry matter content, a desirable character, and for resistance to physiological deterioration at the same time. Furthermore, most lines apparently resistant to this type of deterioration eventually suffer microbial deterioration after about ten days. It is a moot point whether resistance to deterioration for such a short period would resolve many of the problems associated with cassava perishability.

In their comprehensive review on cassava storage, Ingram and Humphries (5) mentioned various traditional methods such as packing in mud and structures similar to potato clamps used in Europe. Booth (1) refined the potato clamp method and developed a storage system using boxes filled with moistened sawdust. These systems are somewhat costly and difficult to manage and have not, up to the present, been adopted on a commercial scale. Oudit (6) suggested that fresh cassava could be stored for up to one month in polyethylene bags with no extra treatment.

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During visits to cassava-growing areas, the authors and other members of the CIAT Cassava Production Systems team observed that in many local markets the cassava roots were sold while still attached to the stem. The vendors claimed that the roots deteriorated much more slowly under these conditions than when removed from the stem.

Booth (1) showed that roots kept under conditions of high humidity "cured" and physiological deterioration was prevented; however, as temperature increased microbial deterioration occurred rapidly.

We have attempted to develop simple methods that may readily be adopted to control both physiological and microbial deterioration of the harvested roots. In the former case both maintenance of high humidity and leaving roots attached to the stems have been the basis, whereas in the latter case, use of protectants and sterilants were evaluated for preventing microbial rotting.

Material and methods

The symptomatological definition of the two reported types of deterioration in cassava roots (1) was determined by general observations on stored roots of different varieties. The severity of these two types of deterioration was evaluated by following Booth's scale of deterioration (3), considering 0 as healthy roots and 4 as the most affected.

Physiological deterioration

The control of physiological deterioration was investigated by (a) pruning the aboveground part of the plants before harvesting and (b) by using different packing systems.

Pruning

One-year-old plants of two varieties susceptible to physiological deterioration (M. Colombia 22 and M. Colombia 1802) were used in the first trial. Plants were pruned back to 20 cm aboveground and harvested 7, 14 and 21 days after pruning. Half of the roots were stored without the stem and the others with the stem section attached. Roots were stored in the field under an open-sided palm hut and readings taken every five days. Deterioration was determined on 20 roots/variety/time of storage. A second trial included six varieties (M. Colombia 45, M. Colombia 1807, CMC 29, CMC 92, M. Mexico 59 and Popayán), which in previous trials had showed different degrees of deterioration.

To determine the effects of temperature and humidity on deterioration, M. Colombia 22 was pruned 14 or 21 days before harvest. Roots were detached from the stems at harvest; half were sliced at both ends and half were left whole. These roots were stored at 35 and 45°C and 20, 40, 60 and 80 percent relative humidity for 0, 6, 12 and 24 hours. Deterioration was evaluated daily on 10 roots per treatment for 20 days.

Packing systems

Twenty fresh, recently harvested one-year-old M. Colombia 113 roots were packed in burlap sacks or bags made of paper, polyethylene-lined paper, or transparent polyethylene. Bags were stored in an open-sided palm hut, and every five days the root deterioration of 3 bags per treatment was recorded as previously. The same trial was later repeated with freshly harvested roots of Llanera and M. Mexico 23.

Microbial deterioration

To control microbial deterioration sodium hypochlorite and Manzate (manganese ethylene bisdithiocarbamate) were used to treat the roots; the former because of its sterilizing effect without leaving toxic residues and the latter because of its protectant effect with low reported toxicity (7), as well as its availability on the market. The combined products were suspended in water at increasing-decreasing concentrations of 5×10^2, 1×10^3, 2×10^3, 3×10^3 and 4×10^3 ppm a.i. of Manzate and 5×10^3, 1×10^4, 1.5×10^4, 2×10^4 and 2.5×10^4 ppm a.i. of sodium hypochloride. Roots were immersed in the suspension for 3 to 5 minutes before packing them in paper-lined polyethylene bags. Readings of deterioration were taken, as above, every five days.

In order to determine whether light had any effect on chemical degradation after treatment which would lead to microbial deterioration during storage, roots of Llanera, M. Colombia 113 and M. Mexico 23 were packed in transparent, red, green and black polyethylene and polyethylene-lined paper bags after treating the roots with 3 x 10^3 ppm a.i. of Manzate and 1 x 10^4 ppm a.i. of sodium hypochloride. Readings were also taken as above every 5 days.

Results

Physiological deterioration is characterized by a dry brown to black necrosis, normally appearing in the form of rings around the periphery of the cortex. This deterioration appears within the first 48 hours after harvesting, depending on varietal susceptibility, and ends in dehydration. Microbial deterioration commonly initiates as vascular streaking, followed by soft rot, fermentation and maceration of the root tissues. This type of deterioration, which does not occur in any special order, is normally noticeable 5 to 8 days after harvesting, depending on the soil microbial flora able to metabolize cassava roots and on the intensity of damage to roots at harvest (Fig. 1).

Pruning

When plants were pruned before harvest, the percentage of deterioration decreased with the time from pruning to harvest up to 14 to 21 days; leaving more time between pruning and harvest had little effect. Roots left attached to the stem piece always deteriorated more slowly than those without the stem (Fig. 2). Varieties without any treatment differed in susceptibility to deterioration (Fig. 3); for example, M. Colombia 1807 and M. Colombia 22 were very susceptible whereas M. Colombia 1802 and M. Mexico 59 were moderately resistant. After 21 days of pruning, however, the first two varieties showed less deterioration when treated than the last two, which were more resistant without treatment. Hence the reaction of varieties to the pruning treatment varies and resistance without treatment is not related to resistance with treatment.

Damaged roots generally deteriorate more rapidly than undamaged roots (1); however, after the pruning treatment roots that were cut to simulate damage deteriorated at the same rate as undamaged controls even when held at low humidity to prevent curing. High or low relative humidities did not increase deterioration of roots taken from pruned plants (Fig. 4).

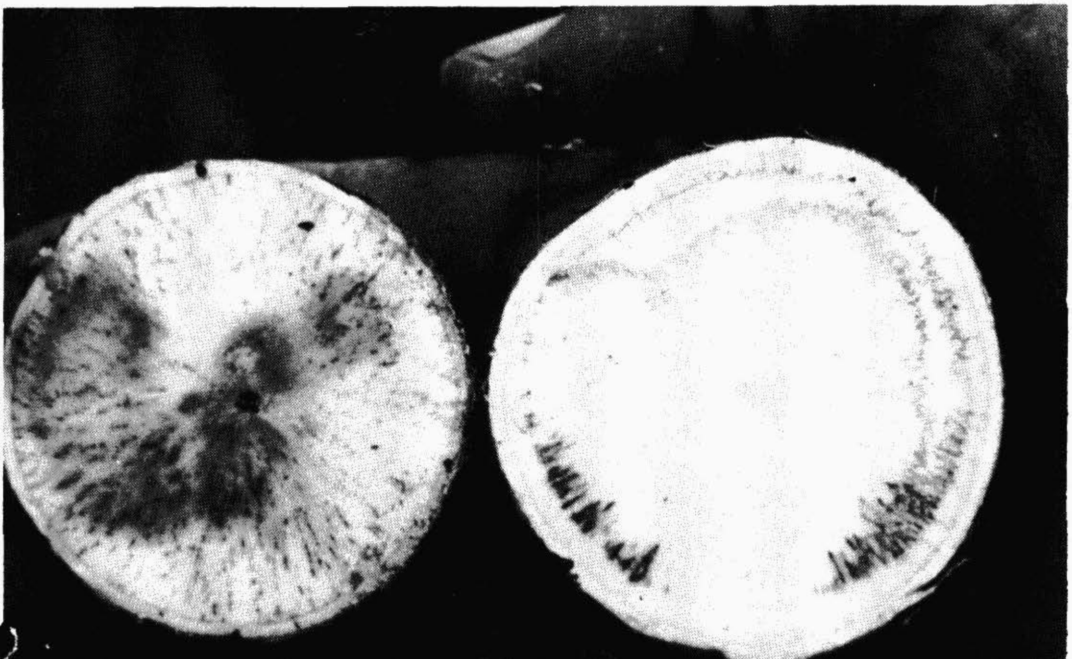

Figure 1. **Cassava root deterioration: left, microbial and right, physiological.**

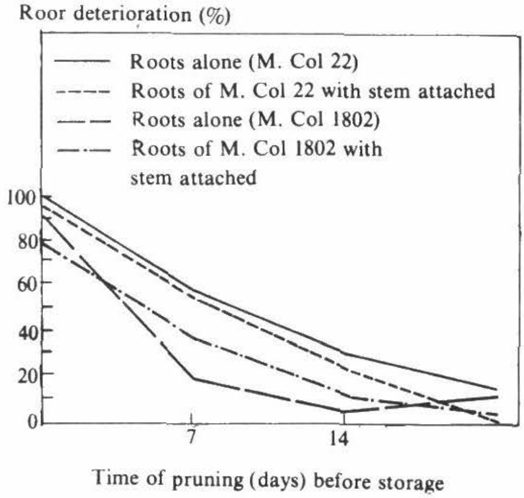

Figure 2. **Effect of pruning on cassava root deterioration after 20 days of storage.**

When roots were stored after pruning, physiological deterioration, which normally occurs during the first two days of storage, was prevented; however, after ten days microbial rotting occurred (Fig. 5), but this was prevented by using a dip of Manzate and sodium hypochlorite (4×10^3 and 2.5×10^4 ppm a.i., respectively).

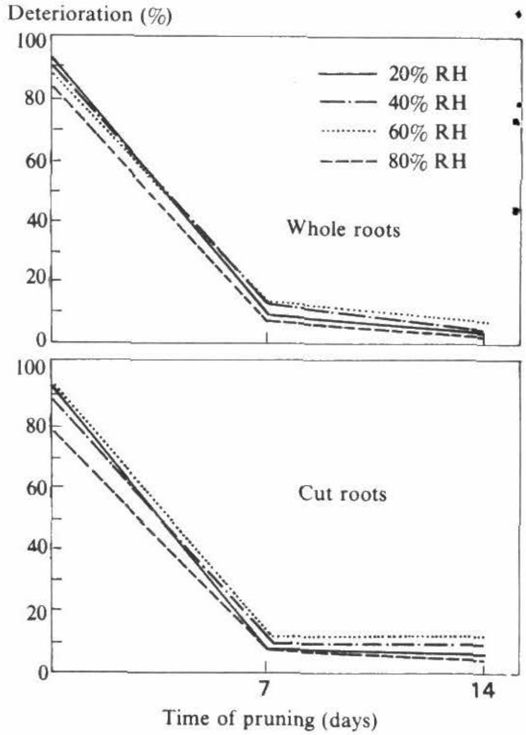

Figure 4. **Deterioration of M. Colombia 22 roots in relation to plant pruning after 20 days'storage at 35°C and 20, 40, 60 or 80% RH for 12 hours.**

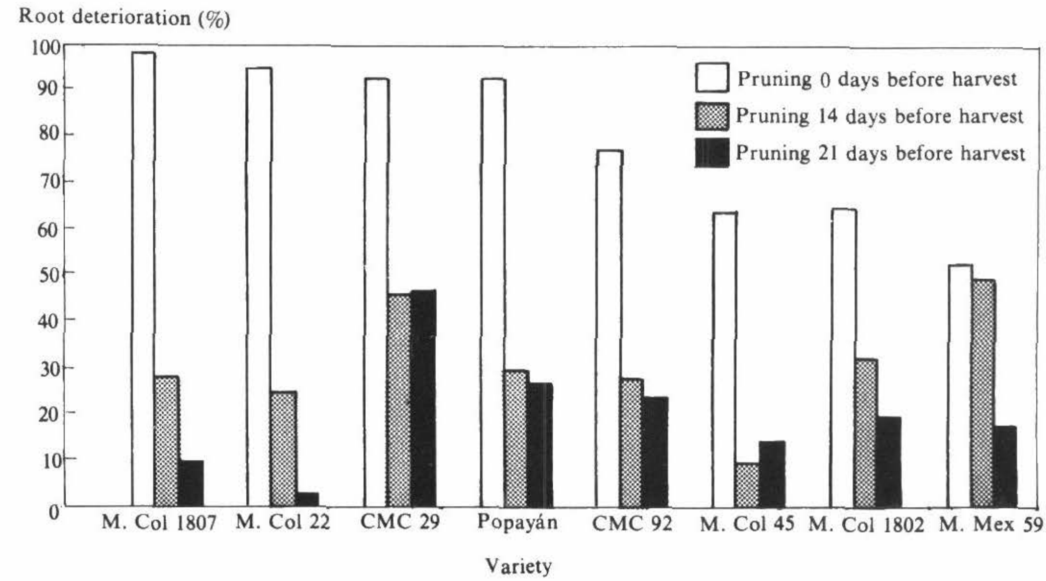

Figure 3. **Root deterioration of 8 varieties pruned 0, 14 and 21 days before harvesting and stored for 20 days.**

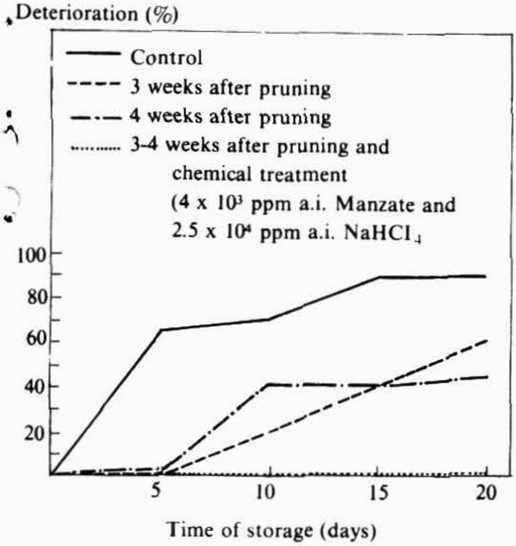

Figure 5. **Effect of plant pruning and chemical treatment on root deterioration (M. Col 113).**

Storage in bags

Storage in burlap and paper bags improved the number of undeteriorated roots when compared with controls (Fig. 6), but treatments still gave a high percentage of both microbial and physiological deterioration even five days after storage. Paper bags lined with polyethylene, on the other hand, prevented physiological deterioration. There was, however, a tendency for microbial deterioration to occur after about ten days, in a manner very similar to that found in the pruning treatments. This tendency was partially prevented by treating the roots with sodium hypochlorite (2.5 x 10^4 ppm a.i.) and completely prevented by a treatment with 4 x 10^4 ppm a.i. of Manzate (Fig. 7). Further trials showed that this concentration of Manzate allowed some microbial rot and that at concentrations of 8 x 10^4 ppm a.i., excellent control was always obtained (Fig. 8). Preliminary studies on quality showed that HCN levels were apparently reduced during storage and that eating quality was improved by time of storage if physiological deterioration was prevented.

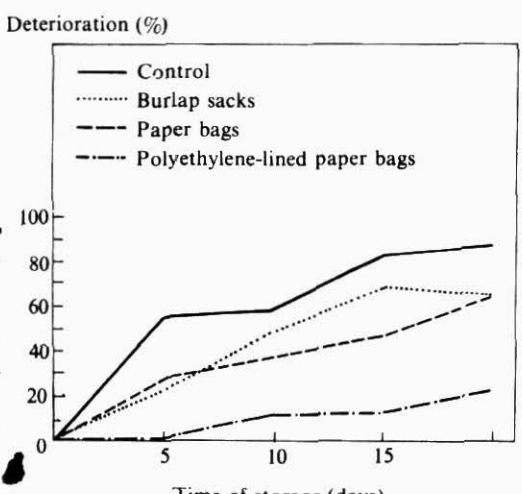

Figure 6. **Effect of storage in bags on cassava (M. Col 113) root deterioration.**

It appears that light does not influence the protectant effect of the chemical used. All roots kept in polyethylene bags with different colors deteriorated at the same rate.

General discussion

Our results with regard to the definition of the two types of cassava root deterioration were in agreement with those reported by Booth (1), except that vascular streaking appears to be a common symptom. Physiological deterioration develops as

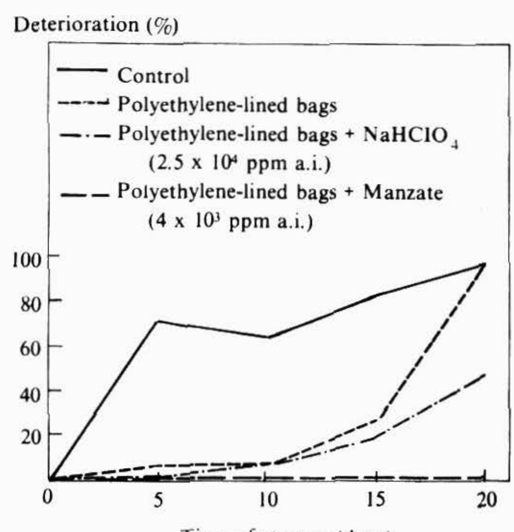

Figure 7. **Effects of polyethylene-lined paper bags and chemical treatments on deterioration of stored roots (CMC 40).**

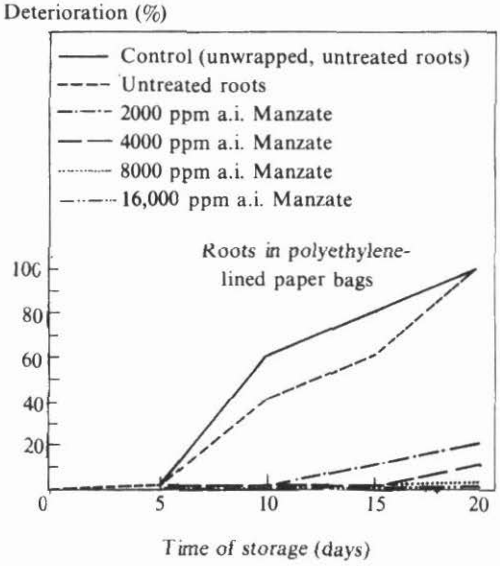

Figure 8. **Prevention of cassava root microbial deterioration with Manzate (CMC 40).**

a dry rot which ends in a light to dark brown discoloration, always found as a ring around the outermost part of the cortex. Vascular streaking, which is also associated with physiological deterioration, is commonly present at the initiation of microbial deterioration as the result of microbial invasion and degradation. This vascular streaking did not have any symptomatological pattern and always ended in tissue maceration, fermentation and discoloration. Microbial activity was always detected.

It appears that physiological deterioration can be prevented both by pruning the plants two to three weeks before harvest and by packing the roots in polethylene bags. If pruning is done and new shoots are allowed to develop before harvest, its effect on physiological deterioration decreases. This suggests that the leaves produce some principle that is translocated to the roots, inducing the initiation of physiological deterioration. Booth (1) reported that this deterioration is associated with mechanical damage to the roots; however, in the pruning system, wounded roots did not show signs of physiological deterioration. It appears that the principle is somehow eliminated or minimized in the roots after pruning; this view is supported by the decline of this type of deterioration when the time from pruning to harvest is extended.

When roots are stored under humid conditions, curing apparently takes place (1) and the consequent healing of wounds prevents physiological rotting. Recent work done by John Marriot while at CIAT suggests that there is another factor involved that is related to water loss. When water loss was reduced by artificial means, physiological deterioration was delayed (Marriot, *personal communication*). This interesting result may explain why high moisture content is loosely correlated with resistance to this type of deterioration. This physiological process may initiate only when a critical low moisture content is reached; varieties whose roots have a low moisture content may reach this level more rapidly. Furthermore, when roots are placed in polyethylene bags, the high humidity environment may not only favor root curing and healing but also reduce water loss sufficiently to prevent physiological deterioration.

Deterioration due to microbial activity is a separate entity, distinct from physiological deterioration. It is induced by a complex of microorganisms able to degrade root tissues. The use of surface sterilants alone is apparently ineffective, probably because sterilization is difficult and there is always an opportunity for reinfections. On the other hand, protectants such as Manzate can be used to prevent reinfections.

It thus seems that protectants can be used to prevent microbial rotting; and either pruning or high humidity conditions, to prevent physiological deterioration. The pruning treatment has some adverse effects on the quality of cassava for fresh consumption. The roots become slightly harder and dry matter content increases slightly, which means that cooking has to be prolonged. On the other hand, it improves the quality of cassava for industrial use. Cassava drying and starch extraction are facilitated by the high dry matter content: transportation costs are reduced and processing is easier.

Although Oudit (6) suggested that storage in polyethylene bags with no further treatment gave no deterioration after 20 days, we always had microbial rotting 7 to 10 days after harvest. However, when polyethylene-lined paper bags, were used in conjunction with protectants, cassava could be stored safely for up to three weeks after harvest with no change in cooking quality. The problems of toxicity from the surface protectants are minimal because the roots are always peeled before cooking. The use of several chemicals and their translocation in the roots remains to be investigated.

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