VIIth Symposium of the International Society for Tropical Root Crops,
Gosier (Guadeloupe), 1-6 July 1985, Ed. INRA, Paris, 1988.

THE EFFECTIVENESS OF STORAGE OF CASSAVA ROOTS IN MOIST MEDIA

(Efficacité du stockage de tubercule de manioc en milieu humide)

Lynda D. WICKHAM

The University of the West Indies
St. Augustine, Trinidad, W.I.

SUMMARY

The effectiveness of storage of 3 cultivars of cassava roots in moist media is reported. Consideration is given to the type of media used, the incidence of rotting and vascular streaking, the physical condition and the cooking quality of the tubers after storage. Physical and physiological changes during storage are discussed.

RESUME

L'efficacité du stockage de 2 "cultivars" de tubercules de manioc en milieu humide a été étudiés. Sont pris en considération, le type de milieu utilisé, l'incidence de la pourriture et des stries vasculaires, les paramètres physiques et la qualité à la cuisson des tubercules après stockage. Les changements physiques et physiologiques durant le stockage sont discutés et des conditions optimales de stockage recommandées.

INTRODUCTION

The utilization of cassava roots in the fresh state is severely restricted by the development of vascular streaking, a physiological disorder characterised by discolouration of the vascular system, within one to seven days after harvest. Two types of deterioration have been identified in the cassava (BOOTH, 1976). The first, termed primary deterioration, has been recognised as a physiological disorder (MONTALDO, 1973 ; BOOTH, 1976 ; NOON and BOOTH, 1977) and the second, secondary deterioration, has been recognised as being due to pathogenic invasion (BOOTH, 1976). It has been noted also that both types of deterioration need to be controlled if storage methods are to be effective. During the years, several methods have been developed to prevent the development of this disorder. The most important factor being the restriction of the loss of moisture as soon after harvest as possible (MARRIOTT, BEEN and PERKINS, 1974 ; BOOTH, 1977).

For the utilization of the cassava root in the fresh form as a boiled vegetable however, the prevention of vascular streaking is not the only consideration. The cooking quality of the roots is very important. Loss in quality in the form of changes in texture of the cooked root is known to occur in cassava. Instead of cooking to a mealy, floury or soft texture as in characteristic of the particular cultivar, the root boils to a hard crunchy consistency and is unpalatable. Such roots can only be used to proceduce various processed products for consumption.

The objective of this study was to examine the effectiveness of storage of cassava roots for fresh consumption under moist conditions with respect to post harvest deterioration, general appearance of the roots and cooking quality after storage.

MATERIALS AND METHODS

Three locally important cultivars, White Stick, Maracas Black Stick and MCol22 were used. Roots were selected for use as soon as they were deemed of good eating quality and only roots with minimal physical damage were used. Large broken roots were trimmed with a clean cut before storage. Roots were harvested and stored, washed or unwashed, in lined cardboard boxes in contact with moist sawdust, red sand, a fine sand used as building material and readily available, or a red sand and sawdust mixture. Roots were also stored in boxes with a polyethylene overlay covering the roots to restrict the amount of contact between the medium and the roots. The respective medium was then placed over the sheet of polyethylene. Roots were either washed in water alone before storage or washed in water followed by a 5 minute dip in a solution of sodium hypochlorite, 1 per cent benlate or 1 per cent dithane M45.

The medium was kept moist by sprinkling with a fine spray of water once the external layers appeared to be drying out. The moisture content of the sand used was 20 per cent, the sawdust 80 per cent and the sand and sawdust mixture 50 per cent. Tubers were examined weekly for the development of vascular streaking during storage and also for the development of discolouration 1 week after removal from the moist medium and return to ambient conditions. Stored tubers were also checked weekly for cooking quality and general physical appearance. Roots from the crop left in the field were harvested and sampled at intervals to assess cooking quality.

Treatment was done with three batches of roots of each cultivar and each batch consisted of 10 boxes, each containing 15 roots.

RESULTS

All media used were effective in preventing the development of vascular streaking provided that roots were placed in the moist storage environment within 8 hours of harvest and adequate provision was made to prevent moisture loss from the roots prior to storage.

The incidence of fungal and bacterial infections was extremely variable in roots which were simply washed and stored or stored without washing. The quantity of spoiled tubers varied from 0 per cent to 100 per cent in some batches. the inclusion of a fungal dip or treatment with sodium hypochlorite improved the storage ability of the roots as a result of the reduction in the incidence of soft rots, but there was also a great deal of variability with these treatments. The pattern was the same for different media used.

After removal from storage under moist conditions roots developed vascular streaking within one week during the early storage period. However, the intensity of the discolouration one week after removal was reduced with increasing storage time and eventually vascular streaking did not develop in roots of White Stick on removal to ambient conditions after they had been stored for 11 weeks. There was no vascular streaking in MCol22 and Maracas Black Stick after storage for 13 and 14 weeks respectively. Generally, new soft rots did not develop on roots which had been stored longer than two weeks if the storage environment remained fairly undisturbed and if there were no rotting tubers in close proximity.

Physical appearance of roots

Callus eruptions appeared on the surface of stored roots as early as 2 days after placing under moist conditions. Generally early callus development was greater in roots of White Stick and Maracas Blackstick than in MCol22. Areas of exposed starch storage tissue were cured by the end of the first week.

Production of small adventitious roots followed the development of callus in all three cultivars. These roots were concentrated towards the distal end of the root, and developed as long as the medium was kept moist. In Maracas Black Stick some roots grew to in excess of 60 cm within 4 weeks.

After 4 weeks storage there was pronounced callus development at the distal end in roots of all three cultivars and in White Stick there was evidence of retranslocation of reserves in 10 per cent of the stored roots. This was seen as polar growth on the side and distal end of the roots. By six weeks storage secondary adventitious roots in White Stick began accumulating storage material as daughter storage roots developed. Development of secondary storage roots in MCol22 and Maracas Black Stick began after 7 and 7 weeks respectively. In roots which did not have profuse secondary adventitious root growth, retranslocation of stored material evidenced by growth at the distal end, was more marked.

Marked development of fibrous, lignified tissue also occured at the distal end accompanying secondary storage root development. There was also the development of a spongy appearance and large cavities in the storage tissue of some roots during storage. This often was more evident after removal from the moist medium and leaving at ambient for 1 week.

Generally the external physical appearance of the stored roots deteriorated with prolonged storage under moist conditions. Root and callus growth as well as discolouration from contact with the moist storage medium contribuated to this.

Cooking quality of roots during storage

Roots of all cultivars maintained excellent cooking quality for the first 6 week of storage. After 6 weeks storage portions of some roots of White Stick did not cook to the normal texture and by 11 weeks after storage about 75 per cent of tubers were not cooking to a desirable texture either wholly or in part. Roots of MCol22 began to show poor cooking characteristics after 8 weeks storage and those of Maracas Black Stick after 9 weeks. Loss of cooking characteristics was generally first evident in a small percentage (less than 10 per cent) of stored roots towards the head end and near the central vascular bundle. Loss in cooking quality progressed slowly so that by 12 weeks after harvest about 50 per cent of roots of Maracas Black Stick and MCol22 still had good cooking quality. Roots which were left in the field were still cooking after 17 weeks.

DISCUSSION

The results indicated that the different media used for storing cassava were equally effective in preventing vascular streaking development. However, prolonged contact with the moist medium resulted in discolouration of the external surface and contributed to loss in quality. The results also indicate that, as had been already established

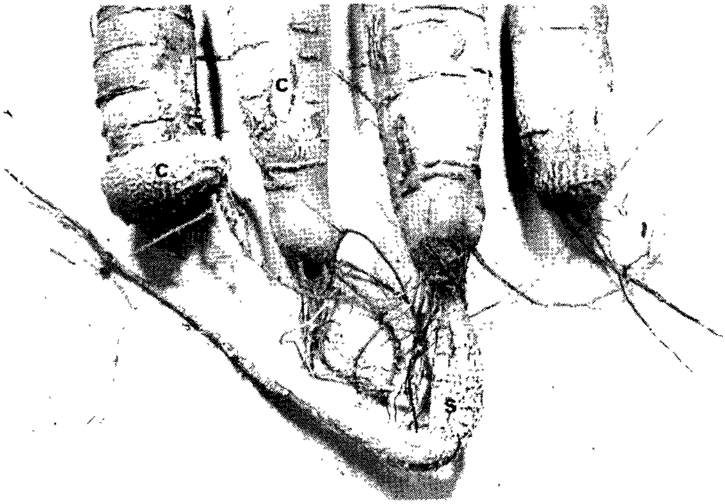

Photo 1 : Cassava roots stored in moist medium for 13 weeks showing callus tissue development on the surface, root growth at distal end, and secondary storage root development

c : callus tissue
r : roots developed in storage
s : secondary storage root

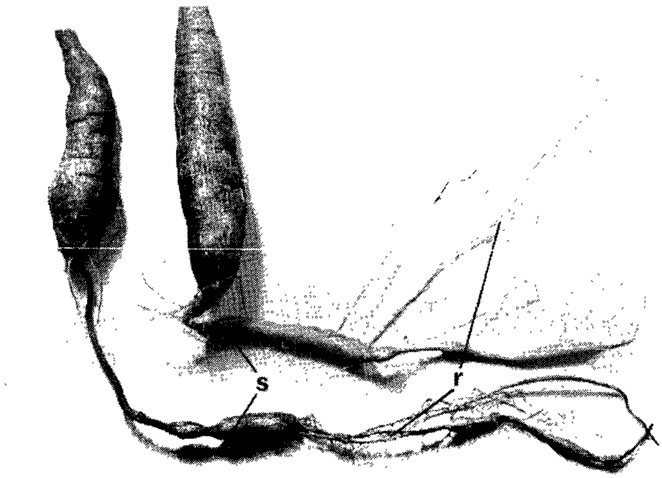

Photo 2 : Cassava roots stored for 15weeks showing root growth at distal end and the development of secondary storage roots during storage

(BOOTH, 1976), postharvest deterioration in cassava has a pathological component and therefore storage under moist conditions, although effective for the prevention of the development of vascular streaking, is only successfull when adequate measures are taken to control post-harvest pathological invasion.

Although it was found that vascular streaking did not develop on removal of stored roots to ambient conditions after several weeks storage, the stage at which this occurred also coincided with rapid moisture loss and the time of reduced cooking quality of the roots. Thus the prospect of short term storage of roots under controlled conditions followed by storage under normal tropical ambient conditions is not feasible for fresh utilization of cassava roots. Additionally, the loss in cooking quality observed in stored roots was found to occur before that in roots left unharvested in the field. For this reason too, the long term storage of roots under moist conditions is contra-indicated. The time of harvest of the roots for storage probably has some effect on the length of time of retention of good cooking quality but this necesitates further investigation. The development of callus tissue, secondary adventitious roots and finally daughter storage roots occurred with prolonged storage of the roots. This detracted from the physical quality of the roots and from this aspect alone, long term storage under moist conditions is undesirable. Roots also became fibrous as a result of secondary thickening at the distal end. Additionally, such roots also lost their cooking quality making long term storage under moist conditions ineffective for the fresh utilization of the roots.

The cassava root is an organ of storage and not propagation and from all appearances, never produces a shoot under normal conditions. The root, probably, plays some role in regrowth of the vegetative parts of the plant after a period of adverse environmental conditions such as a period of drought. The stored carbohydrate probably acts as both an energy source and a source of building blocks for metabolic and physiological activity which result in bud development and elongation. This capacity to act as a retranslocation organ or source apparently becomes operative after prolonged storage under moist conditions. The high humidity encourages root and callus development and stored material is transferred from the mother root into developed adventitious roots and they in turn become daughter or secondary storage roots.

The similarity between this development and the production of daughter tubers in the potato (*Solanum tuberosum*) and the yam (*Dioscorea* spp.) is noteworthy especially since the potato and yam are both organs of propagation as well as storage and can be used to generate new plants. In the yam tuber under special circumstances e.g. prolonged storage as a result of gibberellic acid treatment, without exposure to a moist environment, daughter tubers develop, without exposure to a moist environment, daughter tubers develop (WICKHAM, PASSAM and WILSON, 1984). It is clear, in the present case, that the institution of the shoot is not a requirement for the development of storage organs. It appears that the presence of a carbohydrate source, in this case the storage root, the physiological mechanism necessary for the transfer of metabolites, and an organ with sink capacity is all that is required in this case.

These physical changes, reflecting metabolic and physiological activity, no doubt contributed to the loss of cooking quality of the stored roots. The fact that roots of White Stick, the cultivar in which the changes occurred first, showed loss of cooking quality before roots of MCol22 and Maracas Black Stick, in which secondary storage root formation and secondary thickening occurred later, supports this. It is evident therefore that removal of roots from the field for storage under the conditions discussed here is a disadvantage with respect to retention of cooking quality when compared to leaving roots unharvested since unharvested, stored roots maintain their cooking quality for a longer time. It is possible that prevailing environmental conditions and manipulation of harvest time may affect these results and so further investigations are warranted in this area.

The effectiveness of moist media storage of cassava roots is reduced with increasing length of storage time for the reasons already discussed. In the light of this, any measure that would result in the decreased metabolic activity of the stored roots and reduce root and callus formation should improve the effectiveness of moist storage. Perhaps the use of growth regulators either pre- or post- harvest may hold some potential for increasing the effectiveness of this storage practice.

LITERATURE CITED

BOOTH, R.H. 1976. Storage of fresh cassava (*Manihot esculenta*). 1. Post-harvest deterioration and its control. Expl. Agric. 12 : 103-111.

BOOTH, R.H. 1977. Storage of fresh cassava (*Manihot esculenta*). 2. Simple storage techniques. Expl. Agric. 13 : 119-128.

MARRIOTT, J., BEEN, B.O. and PERKINS, C. 1974. Storage of fresh cassava roots in moist coir dust. Proc. Caribbean Food Crop Soc. 12th Annual Meeting, Jamaica, 1974. 12 : 79-82.

MONTALDO, A. 1973. Vascular streaking of cassava roots. Trop. Sc. 15 (1) : 39-45.

NOON, R.A. and BOOTH, R.H. 1977. Nature of post-harvest deterioration of cassava roots. Trans. Br. Mycol. Soc. 69 (2) 287-290.

WICKHAM, L.D., PASSAM, H.C. and WILSON, L.A. 1984. Dormancy responses to post-harvest application of growth regulators in *Dioscorea* species. 2. Dormancy responses in ware tubers of *D. alata* and *D. esculenta*. J. Agric. Sc. Camb. 102 : 432-436.