This book is provided in digital form with the permission of the rightsholder as part of a Google project to make the world's books discoverable online.

The rightsholder has graciously given you the freedom to download all pages of this book. No additional commercial or other uses have been granted.

Please note that all copyrights remain reserved.

About Google Books

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Books helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at http://books.google.com/

CIAT

Centro Internacional
de Agricultura Tropical

Conservation of cassava roots in polythene bags

Study guide

To be used as a supplement to the audiotutorial unit on the same topic

Digitized by Google

The Centro Internacional de Agricultura Tropical (CIAT) is a development-oriented, agricultural research institution dedicated to the application of science towards lasting alleviation of hunger and poverty in developing countries.

CIAT is one of 13 international agricultural research centers under the auspices of the Consultative Group on International Agricultural Research (CGIAR).

The core budget of CIAT is financied by a number of donors. During 1989 these CIAT donors include the countries of Belgium, Canada, China, France, the Federal Republic of Germany, Italy, Japan, Mexico, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States of America. Organizations that are CIAT donors in 1989 include the European Economic Community (EEC), the Ford Foundation, the Inter-American Development Bank (IDB), the International Bank for Reconstruction and Development (IBRD), the International Development Research Centre (IDRC), the Rockefeller Foundation, and the United Nations Development Programme (UNDP).

Information and conclusions reported herein do not necessarily reflect the position of any of the aforementioned entities.

Digitized by Google

Series: 04SC-07.06
August, 1989

Conservation of cassava roots in polythene bags

Scientific content:

Christopher Wheatley, PhD

Production:

Fernando Fernández O., A.E.
Luz María Medina L., A.E.

Centro Internacional de Agricultura Tropical, CIAT
Cali, Colombia

This One
7EBA-5LC-QL22
Google

Centro Internacional de Agricultura Tropical, CIAT
Apartado Aéreo 6713
Cali, Colombia, S.A.

Bibliographic citation:

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL. 1989. Conservation of cassava roots in polythene bags. Study guide to be used as a complement to the audiotutorial unit on the same subject. Scientific content: Christopher Wheatley. Production: Fernando Fernández O., Luz María Medina. Cali, Colombia. CIAT 33 p. (Series: 04SC-07.06).

Individuals or entities interested in reproducing the study guide or any of its other components by any method should obtain prior authorization in writing from CIAT.

Digitized by Google

Contents

Digitized by Google

Digitized by Google

Objectives

The purpose of this unit is to train those interested in the conservation of cassava roots in polythene bags, as a method for marketing cassava for human consumption.

This purpose will have been accomplished if the person is able to:

- Identify the types of deterioration that occur in fresh cassava roots once they have been harvested.
- List the mechanisms whereby storage in polythene bags makes it possible to conserve the roots with no deterioration for a prolonged period of time.
- Describe the procedure for conserving fresh cassava in polythene bags.

Digitized by Google

Digitized by Google

Introduction

The importance of cassava (*Manihot esculenta*) as a food is due to the fact that it is an inexpensive source of calories, especially for the low-income populations in the tropical regions of the world. This has led scientists to dedicate significant efforts to the development of higher yielding varieties and to design low-input solutions and appropriate technologies for improving production of the crop. The application of this technology in on-farm trials indicates that it is possible to increase production of the crop.

The increased utilization of cassava as a human food and for other uses, which would make the transfer of this technology relevant, has been blocked by the rapid deterioration that the roots undergo after they are harvested. The high perishability of cassava not only increases the costs and risks for wholesalers and retailers, but also leads to considerable losses, which explains the high marketing markups that this product has in order to compensate for the appreciable volume of roots that are lost.

In order to solve this problem and increase the demand and options for commercializing cassava, CIAT, through a joint research program with the Overseas Development and Research Institute (ODNRI) in London, has been searching for methods to conserve cassava roots after their harvest; which are low cost, and which make it possible to store them for prolonged periods of time. Of the methods studied, the most promising has been the packing of the roots in polythene bags and then treating them with a fungicide.

The present unit deals with aspects related to the postharvest deterioration of the cassava roots and its prevention by conserving the roots in polythene bags.

Digitized by Google

Digitized by Google

Types of postharvest deterioration in cassava roots

Once they are harvested, cassava roots can undergo two types of deterioration: one physiological and the other microbial.

The first type of deterioration to appear is physiological, whereby the root tissues turn bluish black, especially near the xylem (Figure 1). This deterioration is caused by the postharvest accumulation of certain phenolic compounds, which are polymerized to form the bluish black pigments.

Visible signs of physiological deterioration appear 24 to 48 hours after harvest; but before this occurs, the roots already show a brilliant blue fluorescence under ultraviolet light due to the accumulation of a phenol known as scopoletin, which is a sure indication that deterioration has begun. Physiological deterioration begins in the wounds, which are almost always produced at the distal and proximal ends of the root during the process of harvesting.

Secondary or microbial decomposition begins from the fifth to seventh day after the roots are harvested. This deterioration appears initially in the form of a vascular streaking, similar to that observed in tissues with physiological deterioration; afterward this turns into a soft rot, accompanied by fermentation and maceration of the tissues (Figure 2).

The knowledge of the mechanisms responsible for postharvest deterioration make it possible to apply various principles in the design of storage systems that will prevent or eliminate deterioration.

Physiological deterioration, which requires oxygen for its development, involves enzymatic reactions; because of this, such deterioration can be prevented by impeding the access of oxygen to the parenchymatous tissues or by inhibiting the enzymatic reactions.

Digitized by Google

Figure 1. Because of physiological deterioration, the tissues close to the xylem turn dark blue.

Figure 2. Microbial deterioration first becomes manifest in the form of vascular streaking and then soft rot.

Digitized by Google

Microbial deterioration, which is associated with the activity of pathogenic microorganisms, is favored by environments with a high relative humidity and high temperatures, especially in roots with mechanical damage. In etiological studies, fungi of the genera *Penicillium*, *Aspergillus*, *Rhizopus* and *Fusarium* have been isolated, as well as several species of *Bacillus*, *Pseudomonas* and *Corynebacterium*.

Some storage conditions make it possible to eliminate the factors that favor root deterioration. For example, storage in an atmosphere of nitrogen or in a vacuum prevents physiological deterioration because there is no oxygen in the environment. This may also be accomplished by covering the cassava roots with thin layers of paraffin, which act as artificial barriers, preventing the penetration of oxygen in the tissues. On the other hand, the enzymatic processes involved in physiological deterioration can be inhibited by storing the roots under low temperature conditions. For example, at 2°C polyphenoloxidase and other enzymes are prevented from forming the pigments which are typical of the symptoms of physiological deterioration.

Another way to prevent physiological deterioration is to store the roots under conditions that favor the healing of wounds, which are a normal occurrence and which are almost always the point where deterioration begins. It has been observed that the harvested cassava root can form a new layer of suberised cells over damaged tissues; this layer acts as a protective barrier. This process, known as curing, is accomplished by storing the roots in an environment of 30°C and 85% relative humidity, and takes 4 to 5 days.

Unfortunately, this same environment of high moisture and temperature, appropriate for curing the root wounds and thus for preventing physiological deterioration, also stimulates microbial deterioration. The growth of fungi and bacteria can be so rapid that root rot can begin before the root forms the layer of new protective cells. To prevent this problem, the relative humidity should be reduced to a level that will retard the growth of the pathogens but that will not stimulate physiological deterioration. Another solution is to treat the roots before storing them with an antimicrobial agent that is innocuous to humans and that does not leave significant residues in the parenchymatous tissues of the root.

It can be deduced from the foregoing that the prevention of physiological deterioration requires the use of specialized technology such as refrigeration

Digitized by Google

or paraffin plants, which are often very costly and difficult to use. As the current market for fresh cassava in developing countries is not sufficiently developed to make it feasible to use such equipment, the search for effective, simple and low-cost methods of storage becomes a priority, for the benefit of all concerned: the farmer as well as the wholesaler, the retailer and the consumer.

CIAT and ODNRI have developed a methodology that consists of packing the cassava roots in polythene bags and treating them immediately with a fungicide. The environment within the bags is characterized by high temperatures and moisture conditions, which permit the root wounds to cure, and any possibility of microbial growth is prevented by the action of the fungicide. In this way this storage system makes it possible to prevent both physiological and microbial deterioration. The results obtained thus far demonstrate and confirm this, with the additional advantage that it is a simple system, easy to manage and of low cost. Using this system, storage times of 2 to 3 weeks can be relably achieved with no loss of eating quality.

Digitized by Google

Conservation of fresh cassava in polythene bags

This conservation technique consists of packing the roots in polythene bags and treating them immediately with a fungicide based on thiabendazole.

The complete process is comprised of the following steps: (a) testing the quality of the roots, (b) harvesting and selecting the roots, (c) packing and treating the roots, (d) transportation of the bags to the points of purchase, and (e) the actual marketing of the conserved roots.

Tests of root quality

The successful conservation of the cassava roots depends to a great extent on their quality before beginning the process. There are standards of quality which should be determined previously: cooking quality, quality for conservation, and soundness of the roots.

Cooking quality

Cooking quality is related to the time for cooking or preparing the roots and to their acceptance by consumer taste panels. In order to carry out this test, several cassava plants are selected at random from several lots, the roots are harvested, and several of these are chosen at random. These roots are then submitted to a cooking process.

In the case of boiled, fresh cassava, to have good cooking quality, the roots must fulfill the following requisites:

a. A cooking time of no longer than 30 minutes; they should be neither too hard nor too soft.

Digitized by Google

b. Taste: not bitter nor sweet. The former indicates that the roots have a high cyanide content; the latter, a high sugar content.

c. No fibers and/or lignified tissues within the parenchyma.

d. Texture: firm, but not hard or "glassy"; the parenchyma should be white or yellow in color, never transparent.

Most of these characteristics can only be detected when tasting the pieces of boiled cassava, and not by observing its external appearance (Table 1).

TABLE 1. Quality standards of cassava roots suitable for conservation.

Characteristic	Observations
Cooking time	30 min to be neither too hard nor too soft
Taste	Not bitter nor sweet
Texture	Firm
Parenchyma color	White or yellow

Conservation quality

The quality for conservation takes into account certain morphological characteristics of the root that are related to a variety's suitability for conservation. The following are a few observations in this regard:

- Cylindrical or conical roots with well-developed peduncles suffer fewer physical injuries during harvesting and storage.
- Roots with short peduncles are difficult to separate from the thick main stem; in the process of doing so, the peel is almost always broken and the parenchyma is damaged.
- Round roots suffer longitudinal mechanical damage to the peel during transportation and storage.
- Long roots are easily broken during harvest (Figure 3).

Taking into account the foregoing observations, it has been found that the most appropriate varieties for conservation are those that have medium-sized roots with well-developed peduncles. This type of root presents fewer losses due to physical damage during harvesting, selecting and the later storage of the roots (Figure 4).

Digitized by Google

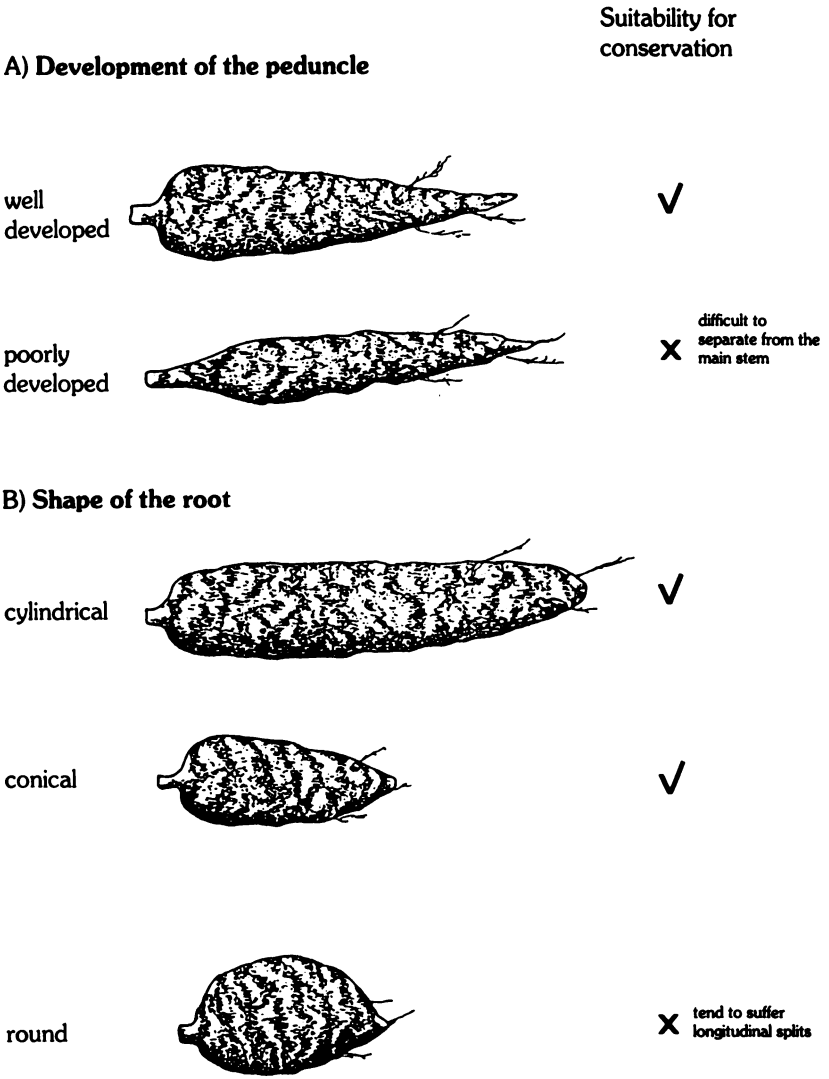

Figure 3. The qualities cassava roots should have for conservation, taking into account the development of the peduncle and the shape of the root.

Digitized by Google

Figure 4. The most suitable roots for conservation are medium in size, with a well-developed peduncle.

Soundness of the roots

Soundness refers to the absence of external or internal rots in the cassava roots. It is important that all roots with rots be discarded because just one affected root—even if it is only at the inicial stages—can cause the total loss of all the roots in one bag.

It is not always easy to detect such rots. For example, internal rots do not always present signs that are visible externally, as is the case of the disease known as "smallpox," which is caused by a fungus transmitted by a subterranean sucking bug (*Cyrtomenus bergi*); thus it is necessary to peel root samples (Figure 5). There are also some stem diseases, which can infect the root through the lignified peduncle. In cases such as these, it is necessary to be especially careful during the process of selecting the roots.

Digitized by Google

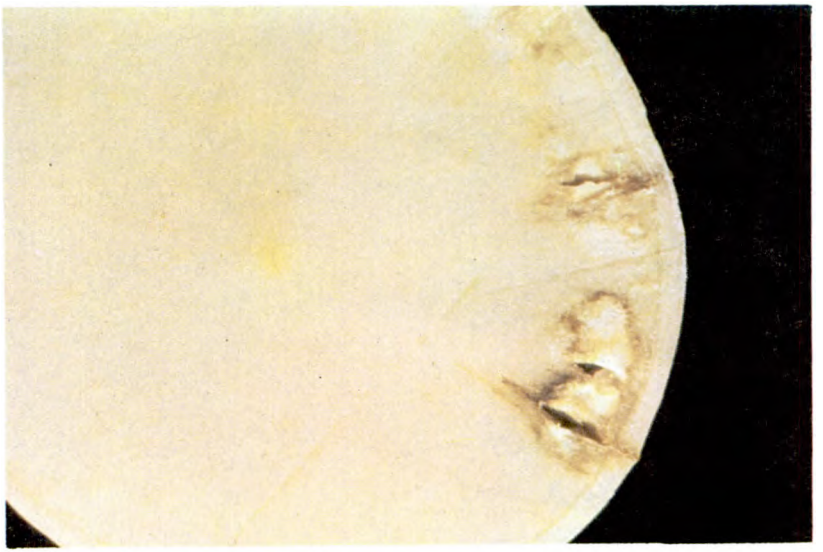

Figure 5. Root affected by the disease known as smallpox.

Harvesting and selecting cassava

Harvesting

Plants are generally harvested at 8 to 12 months of age, as this is when they usually produce the best root yields in the lowland tropics. Harvesting should be done very carefully in order not to break the roots nor cause appreciable physical damage. Figure 6 shows the type of damage and its effect on the suitability of the roots for conservation.

Normally harvesting is done manually, separating the root from the thick main stem with the aid of a machete or a pair of large garden shears. The latter tool is more adequate as it gives a precise, careful cut, causing less damage. When cutting the root, a small piece of peduncle should be left attached so that the parenchyma is not exposed to the open air (Figure 7).

Digitized by Google

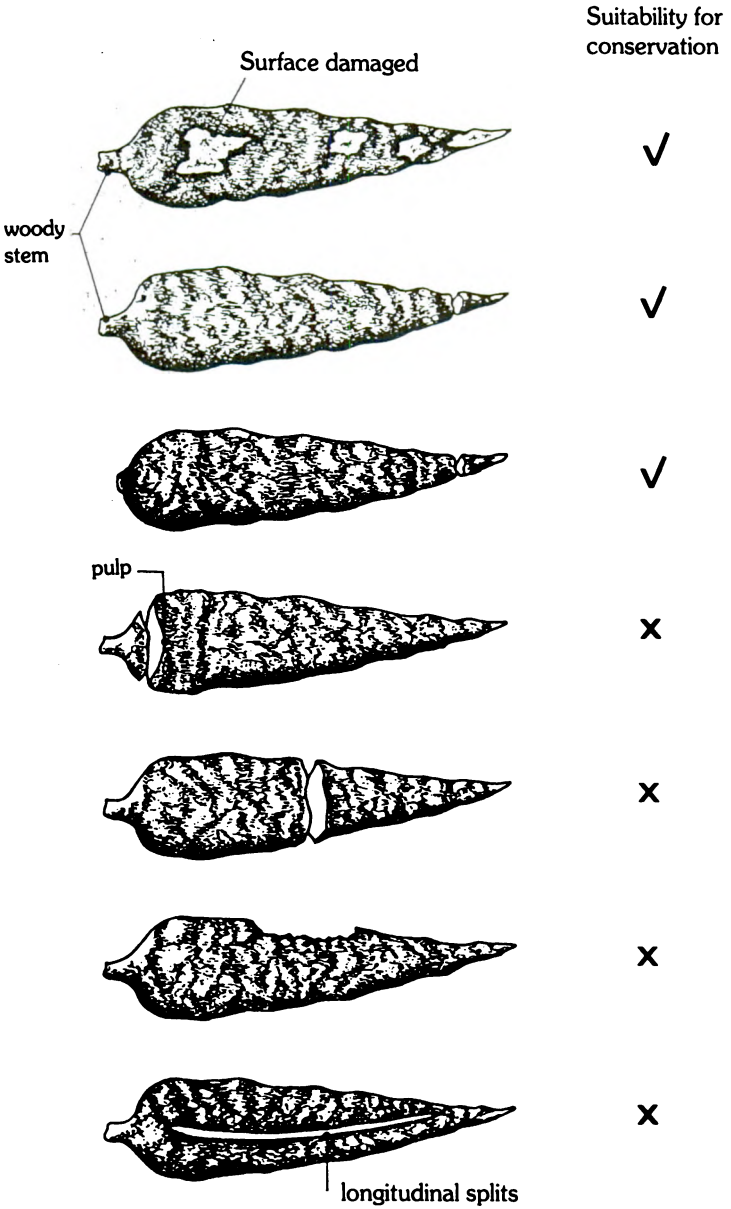

Figure 6. Quality of cassava roots for conservation, taking into account the type of damage that the roots can incur during harvesting.

Digitized by Google

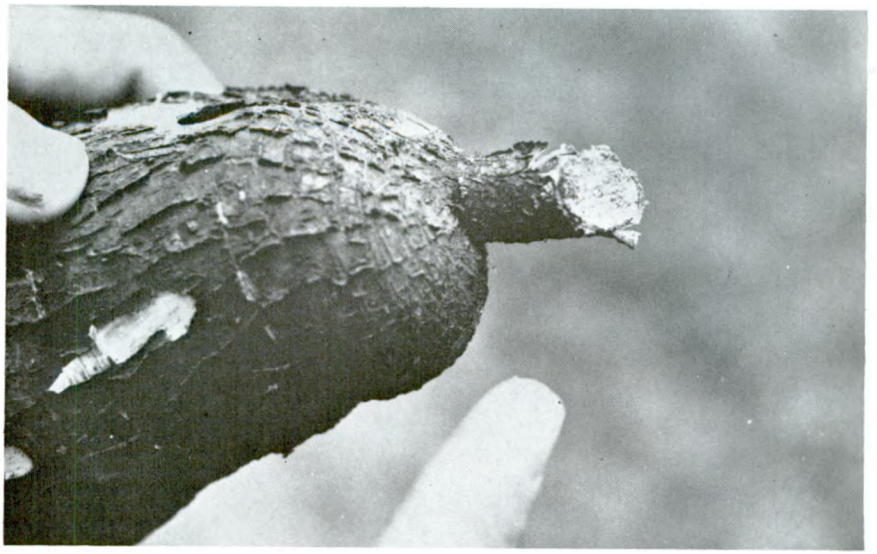

Figure 7. A good practice is to leave a piece of the peduncle attached to the root.

Selection

The harvested cassava is classified into three categories according to the type of root (if it is commercial size or not) and the magnitude of physical damage (Table 2).

TABLE 2. Categories for selecting roots for conservation.

Categories	Type of root	Physical damage	Percentage
A	Commercial	Slight or none	80-90
B	Commercial	Severe	5-10
C	Not commercial	With or without	5-10

Normally about 80 to 90% of the cassava roots are of commercial quality, with little or no physical damage (Category A), which makes them suitable for being treated and conserved. A smaller percentage of the roots are also equally commercial; but as they have severe damage (Category B), they

Digitized by Google

cannot be conserved. It is likely that the proportion of cassava in this category will increase during the dry seasons when harvesting is more difficult. The cassava in Group B can be used for different purposes: the roots can be sold for immediate fresh consumption by nearby populations; used fresh or ensiled for feeding animals; dried for sale to companies producing balanced feeds, or used in the production of starch. The noncommercial small roots (Category C) can also be dried, and in this manner the entire harvest can be used.

Packing and treating the selected roots

General considerations

Before proceeding to pack and treat the roots, several important aspects should be considered: the time between harvesting and between the moment of packing, the effect of the sun on the quality of the roots, and the coordination of the activities in this step.

Time between harvesting and packing. Experimental studies and practical experience both show that the operations of packing and treating the roots must be carried out in the shortest time possible after harvest. A delay of only four hours can cause the total loss of the product because of physiological deterioration. It is recommended, therefore, that the time between harvesting and packing should be less than three hours, which means that the tasks must be carried out in the fields or at a site nearby.

Effect of the sun. The direct exposure of the roots to the sun for prolonged periods increases the possibility of losses because of physiological deterioration. This situation can be prevented by harvesting and packing the roots during the early hours of the morning, late in the afternoon, or under shade at the site of operations.

Coordination of tasks. One way to prevent the foregoing situations is to coordinate the tasks of harvesting, packing and treating the roots, with the purpose of carrying them out as quickly and efficiently as possible.

Digitized by Google

If work groups are formed and each group is assigned a specific task (harvesting, selection, packing, treatment, sealing, etc.), in such a way that there is a permanent flow of work, the results will be more reliable and effective than if all the workers are performing the same tasks in each one of the steps of the process. In this way, the amount of roots will not build up between steps; in fact, in the event that activities must be suspended because of rain or other causes, the time between harvesting, packing and treating the roots will be short.

Materials for treating the roots

For packing and treating the roots, minimal equipment and additional materials are required and should be available at the site of operations. The equipment and materials are as follows:

- A high-pressure portable sprayer, with a maximum capacity of 20 liters.
- A fungicide. Mertect 450 FW is used.
- Polythene bags of 4- and 12-kg capacity. The 4-kg bags measure 21x12 cm and have a thickness or caliber of 0.4 mm. The 12-kg bags are 0.6 mm thick. The size of the bags can vary according to market requirements.
- Information labels. The following information should be included: brand name, date of harvest and packing, weight of the contents, guaranteed conservation time, instructions for handling the product adequately. Another option instead of the labels is to print this same information directly on the polythene bags.
- A scale. This should be in good condition and easy to handle.
- A stapler. This should be adequate for the type of packing that is going to be used, and sufficient spare staples should be on hand. Alternatively, string can be used to seal the bags.

Procedure

The procedure for packing and treating the cassava roots consists of the following steps: packing of the selected roots, treatment of the roots with the fungicide, and transportation of the bags to the points of purchase.

Digitized by Google

Packing. Only the cassava roots that were selected for treatment; that is, those roots of commercial size with no or only very slight physical damage (see Table 2).

The roots should be placed in vertical position inside the bags, with the peduncle facing upward. As the selected roots will not be even in size, it is necessary to pack different sizes in one bag in order to make sure that all the small roots are not packed in the last bags.

A very important activity at this stage is the weighing of the bags to adjust their weight to the bag's capacity. The bags with a capacity of 4 kg, for example, should have that weight; if they have less, it will be bad for the consumer; and if they have more, for the farmer.

Treating the roots. Treatment of the roots is done with a thiabendazole-based fungicide solution, Mertect 450 FW at a concentration of 0.4% and applied to the roots after they have been placed in the plastic bags. The way to prepare the solution and apply the treatment is as follows:

- Prepare the fungicide solution at a concentration of 0.4%. To do this, fill the tank of the sprayer with water (in this case 20 liters) and add 80 milliliters of Mertect (0.4% of 20 liters). This mixture should be mixed vigorously with a stick or using the nozzle of the sprayer. Then put the filter and the cap of the sprayer in place, and the fungicide solution is ready to be applied.

- Apply the fungicide to the roots. To do this, stick the nozzle of the sprayer into each of the bags and spray the roots well, especially the tips of each root (Figure 8).

  In order to treat one 4-kg bag, approximately 100 ml of solution is required. Thus one liter of Mertect 450 FW is sufficient for treating 10 tons of cassava.

- Remove the excess fungicide solution that remains in the bag. This should be done to prevent excess moisture inside the bag and arrest the rapid development of fungi.

Digitized by Google

Figure 8. For treatment with the fungicide, the spray nozzle is introduced into the bags, and all the roots are sprayed.

In order to remove the solution that has built up, carefully turn the bag upside down. This is not very practical, however, because the roots can fall out; and it is an additional activity, which increases the labor requirements. A more practical way is to make small diagonal cuts in the bottom corners of the bags before packing them, or use perforations along the base of the bag. The excess liquid will drain through these holes and will not affect root conservation (Figure 9); and at the same time, they can help regulate the level of moisture in the bags, especially when the harvesting is done during the rainy season when the relative humidity is excessive.

- Close the bags. After folding the top of the bag two or three times, seal it with the stapler. As many staples should be used as necessary to ensure that the bags are well sealed; and if information labels are used, they should be attached with the last staples (Figure 10). Alternatively, bags can be tied shut with string.

Digitized by Google

Figure 9. Through the cuts in the bottom corners of the bag, the excess liquid is drained.

Figure 10. The last step is to attach the information label.

Digitized by Google

Transportation of the bags

The bags with the treated roots should be transported in the same type of vehicles that are normally used for transporting the fresh cassava. At this point, it should be remembered that in the first step of conservation, conditions were created for curing the wounds or the damage that the roots incurred and that this process is very important for their successful conservation. Thus the climatic conditions during transportation should be considered so make sure that the curing process is not affected.

During transportation, it is necessary to ensure that the internal temperature of the bags is approximately 30°C. This means that when the bags are transported in hot climates, it is not convenient to keep them inside the truck for too much time in order to keep the internal temperature from rising above the maximum level (40°C). On the other hand, in temperate or very cold climates, it will be necessary to cover the bags with a canvas in order to protect them from the cold. If the time it takes to transport the bags in these very cold climates (e.g., the Andean zone) is too long, the bags should be left in a very hot climatic environment (30-40°C) for 24 hours prior to the trip in order to ensure that the process of curing the wounds is started before the roots are transported.

It is also necessary to take into account the condition of the roads. If the trip is very long and the roads are in very bad condition, physical damage will occur to the roots, thus affecting their conservation. In these cases, it is recommended that the bags be packed in the truck in such a way that abrasion damage is minimised. It is also possible to use plastic or wooden crates, in which several bags can be placed.

When the conditions for transportation are very bad, the roots suffer physical damage; and the guaranteed time of conservation, which is normally 15 days, is almost always reduced to only 7 to 10 days. This information is very important for both the distributor and the consumer, who can insist that shorter conservation times be specified on the bag labels.

The same conditions of temperature that were described for transporting the roots apply for storage of the bags. Only after the roots have been cured can

Digitized by Google

they tolerate temperatures under 30°C within the bags; but in no event can they tolerate temperatures over 40°C.

Commercialization

Based on commercialization experiences in Bucaramanga and Barranquilla, Colombia, and the marketing studies conducted there, the 4-kg size bags are the most appropriate for the consumer. This amount of cassava is sufficient for the average-sized family (5 members) for one week. The consumer purchases one bag and then keeps the cassava in the same bag while it is being consumed. For those consumers who want to purchase smaller amounts, the retail distributor can sell cassava from larger capacity bags (12 kg). In this case it is the retailer who benefits from the advantages of longer storage, while the consumer also benefits from a product of guaranteed quality and a more favorable price.

Acceptance studies carried out with consumers in Bucaramanga, who were given cassava that had been conserved for 1 and 2 weeks after harvesting, have made it possible to conclude that the consumer does not detect any changes in the cooking quality of these roots and that 90% of them preferred buying the cassava conserved in the bags (Figure 11).

Digitized by Google

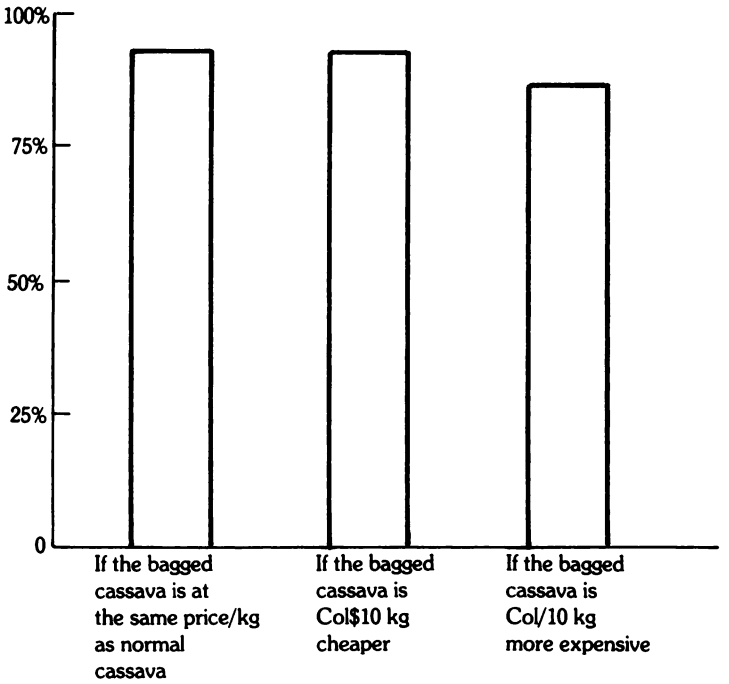

Figure 11. Response of the consumers to the purchase of cassava conserved in bags.

Digitized by Google

Study questions

I. In the blank space of Column A, write the number corresponding to the matching item from Column B.

Column A	Column B
____ Is controlled by preventing excess O_2 in the parenchymatous tissues or by inhibiting enzymatic reactions.	1. *Penicillium*, *Aspergillus*, *Bacillus*, etc.
____ Method developed at CIAT.	2. Bluish black streaks in the form of rings in the periphery of the pulp.
____ Physiological deterioration.	3. Soft rot with fermentation and maceration of the tissues.
____ Associated with microbial deterioration.	4. Physiological deterioration.
____ Microbial deterioration.	5. Packing of the roots in polythene bags and treating them with a fungicide based on thiabendazole.
____ Curing process.	6. Environments of 30°C and 85% relative humidity.

II. Complete the blank spaces.

1. A cassava variety with good cooking quality meets with the following requisites:

Cooking time: _____

Taste: _____

Texture: _____

Consistency: _____

Parenchyma: _____

Digitized by Google

2. The most appropriate roots for conservation are _____ _____ in size with _____ peduncles.

3. When cutting the roots from the main stem, a small piece of _____ should be left attached so that the parenchyma is not _____

4. For each of the categories for selecting roots, give the corresponding characteristics:

	Type	Damage
Category A Category B Category C		

5. For each group, identify the category of roots:

Treatment and conservation: _____
Immediate consumption, animal feed, starch: _____
Animal feed: _____

6. The time between harvesting and packing should be _____.

7. The equipment and materials required for packing and treating the cassava roots are as follows:

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

III. Number the following activities in the order that they should be carried out when treating the roots:

____ Adjust the weight of the bags.
____ Cut the bottom corners of the polythene bags.
____ Put the tip of the sprayer nozzle in the bag and spray all the roots.
____ Place all the roots of Category A in a vertical position in the bags.

Digitized by Google

____ Prepare the fungicidal solution at 0.4%
____ Fold the opening of the bag two or three times and then seal it with a staple.
____ Attach the information label.

IV. In the blank spaces of Column A, write the number that corresponds to the matching item from Column B.

Column A	Column B
____ Fungicidal solution at 0.4%	1. Before transporting the bags to very cold climates.
____ 1 liter of Mertect 450 FW	2. 80 ml of Mertect in a 20-liter sprayer.
____ Transportation	3. Ensure that the temperature in the bags is approximately 30°C.
____ Place the bags in a hot climatic environment for 24 hours	4. 10 tons of cassava.

NOTE: For the correct answers, see the last page.

Digitized by Google

Bibliography and complementary readings

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

BOOTH, R.H. 1976. Storage of fresh cassava (*Manihot esculenta*). I. Post-harvest deterioration and its control. Experimental Agriculture 12 (2): 103-111.

BOOTH, R.H. 1974. Post-harvest deterioration of tropical root crops: losses and their control. Tropical Science 16 (2): 49-63.

BOOTH, R.H.; COURSEY, D.G. 1974. Storage of cassava roots and related post-harvest problems. *In*: Cassava processing and storage: proceedings of an interdisciplinary workshop, Pattaya, Thailand, 1974. Ottawa, Canada, International Development Research Centre. pp. 43-49.

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL. 1983. Almacenamiento de raíces frescas de yuca; guía de estudio para ser usada como complemento de la Unidad Audiotutorial sobre el mismo tema. Contenido Científico: Christopher Wheatley. Producción: Fernando Fernández O., Cali, Colombia. CIAT. 35 p. (Serie 04SC-07.05).

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL. 1973, 1976, 1977, 1979, 1980, 1981, 1982. Annual Report. Cassava Program. Cali, Colombia.

COURSEY, D.G.; BOOTH, R.H. 1977. Post-harvest problems of nongrain staples. Acta Horticulturae. 52: 23-33.

JANSSEN, W; WHEATLEY, C. 1985. Urban cassava markets: the impact of fresh root storage. Food Policy 10: 265-277.

LOZANO, J.C.; COCK, J.H.; CASTAÑO, J. 1978. New developments in cassava storage. *In*: Brekelbaum T., Bellotti, A. and Lozano, J.C. eds. Cassava Protection Workshop, Cali, Colombia. 1977. Proceedings. Cali, Colombia. Centro Internacional of Agricultura Tropical, Series CE-14. pp. 135-141.

Digitized by Google

MARRIOTT, J.; BEEN, B.O.; PERKINS, C. 1979. The etiology of vascular discoloration in cassava roots after harvesting: development of endogenous resistance in stored roots. Physiologia Plantarum 45 (1): 51-56.

MARRIOTT, J.; BEEN, B.O.; PERKINS, C. 1978. The etiology of vascular discoloration in cassava roots after harvesting: association with water loss from wounds. Physiologia Plantarum 44 (1): 38-42.

MONTALDO, A. 1979. La yuca o mandioca: cultivo, industrialización, aspectos económicos, empleo en la alimentación animal, mejoramiento. San José, Costa Rica. Instituto Interamericano of Ciencias Agrícolas of la OEA. 386 p.

MONTALDO, A. 1973. Vascular streaking of cassava root tubers. Tropical Science. 15 (1): 39-46.

NOON, R.A.; BOOTH, R.H. 1977. Nature of post-harvest deterioration of cassava roots. Transactions of the British Mycological Society. 69 (2): 287-290.

OUDIT, D.D. 1976. Polyethylene bags keep cassava tubers fresh for several weeks at ambient temperatures. Journal of the Agricultural Society of Trinidad and Tobago. 76 (1): 63-66.

PACHICO, D.; LONDOÑO, N. de; DUQUE, M. 1983. Economic factors, food consumption patterns and nutrition in Cali, 1982. Seminario Interno, Series SE-4-83.

PASSAM, H.C.; NOON, R.A. 1977. Deterioration of yams and cassava during storage. Proceedings of the Association of Applied Biologist, 85 (3): 436-440.

RICKARD, J.E. 1982. Investigation into post harvest behaviour of cassava roots and their response to wounding. Ph.D. Thesis, London. University of London. 161 p.

RICKARD, J.E. 1981. Study of the production of xylem occlusions and scopoletin in cassava roots in response to injury. Proceedings of the Royal Microscopical Society. 16 (4): 294.

RICKARD, J.E. 1981. Biochemical changes involved in the post-harvest deterioration of cassava roots. Tropical Science 23: 1-2.

WHEATLEY, C.; ORREGO, J.I. 1984. Fresh cassava root storage in polyethylene bags (mimeo).

Digitized by Google

Answers to the study questions

I. 4; 5; 2; 1; 3; 6.

II. 1. 30 min.
not sweet nor bitter
should not have
firm
white or yellow

2. medium; well-developed

3. peduncle; exposed to the air

4.

Type	Damage
Commercial	Slight or none
Commercial	Severe
Not commercial	With or without

5. Category A
Category B
Category C

6. Less than 3 hours

7. a. 20-liter pump
b. Mertect 450 FW
c. polythene bags
d. information labels
e. scale
f. stapler

III. 3; 1; 5; 2; 4; 6; 8

IV. 2; 4; 3; 1

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Training and Communications Support Program
Training Materials Section

Edition: Trudy Brekelbaum
Layout: Didier González C.

Digitized by Google

Digitized by Google