



RESEARCH PROGRAM ON
Roots, Tubers
and Bananas



Training Report: South-South Collaboration for Strengthening Capacities in Assessing the Postharvest Physiological Deterioration (PPD) of Fresh Cassava Roots and Technologies for Shelf-life Extension: Lessons Learnt by the Ugandan Research Team

Extending the shelf-life of fresh cassava roots for increased
incomes and postharvest loss reduction

*Expanding Utilization of Roots, Tubers and Bananas
and Reducing Their Postharvest Losses*



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A broad alliance of
research-for-development
stakeholders & partners



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The CGIAR Research Program on Roots, Tubers and Bananas (RTB) is a broad alliance led by the International Potato Center (CIP) jointly with Bioversity International, the International Center for Tropical Agriculture (CIAT), the International Institute for Tropical Agriculture (IITA), and CIRAD in collaboration with research and development partners. Our shared purpose is to tap the underutilized potential of root, tuber and banana crops for improving nutrition and food security, increasing incomes and fostering greater gender equity, especially among the world's poorest and most vulnerable populations.



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Acronyms and abbreviations

CGIAR	Consultative Group on International Agriculture Research
CIAT	International Centre for Tropical Agriculture
DMC	Dry matter content
EC	European Commission
FCR	Fresh cassava roots
IFAD	International Fund for Agricultural Development
HPLC	High Performance Liquid Chromatography
IIRR	International Institute of Rural Reconstruction
IITA	International Institute for Tropical Agriculture
NaCRRRI	National Crop Resources Research Institute
NARO	National Agricultural Research Organisation
NIRS	Near Infra-Red Spectroscopy
NGOs	Nongovernmental organizations
PMCA	Participatory Market Chain Analysis
PHL	Postharvest losses
PPD	Postharvest physiological deterioration
RH	Relative humidity storage
RTB	Roots, Tubers and Bananas
SSA	Sub-Saharan Africa



1. Introduction

1.1 BACKGROUND

Cassava is an important source of food and income in Uganda and most developing countries at large. In sub-Saharan Africa (SSA), cassava is a major staple providing over 20% of calorific requirements and constituting nearly two-thirds of per capita food production.

However, the full potential of cassava to contribute to food and income security has not yet been realized due to a number of challenges, including its bulkiness and high perishability, poor postharvest management, and lack of storage and processing facilities.

One of the major challenges facing cassava is its rapid postharvest physiological deterioration (PPD). This results into short marketing channels, price discounts, and lower incomes to growers and traders that limit its utilization.

The 'Expanding Utilization of RTB and Reducing Their Postharvest Losses' (RTB-ENDURE) cassava sub project has been designed as part of the efforts under Theme 6 of the CGIAR Research Programme on Roots, Tubers and Bananas (RTB) to '*Promote postharvest technologies, value chains and market opportunities*'.

1.2 THE CASSAVA SUB PROJECT

The Cassava sub project also known as "Extending the Shelf-life of Fresh Cassava Roots for Increased Incomes and Postharvest Loss Reduction" aims at introducing, testing, validating and assessing the efficacy of two technologies for increasing the shelf-life of fresh cassava roots and thereby benefiting growers, traders and consumers along the entire value chain in Uganda. The two technologies include relative humidity storage (RH) and waxing and additional research is conducted to identify best-bet marketing models. It is a two-year highly collaborative research project that involves the following implementing partners and other collaborators: IITA, CIAT, CIRAD, NARO, IIRR and collaborators such as Kyambogo and Makerere Universities, the private sector and the Government of Uganda (GoU).

The research team in Uganda has adopted the steps for product development proposed by Wheatley et al., (1995) comprising of idea generation and screening, and market research (scoping study). The next steps are location/beneficiary selection, technical and consumer research, and pilot testing.

The project is testing and validating commercial, technical, and institutional innovations that:

- 1) Decrease postharvest losses in fresh cassava root (FCR) value chains
- 2) Increase shelf life of FCR
- 3) Increase income from FCR and its products for rural producers
- 4) Increase participation of women in higher and more profitable levels of the value chain and
- 5) Lead to more equitable distribution of benefits between men and women in the community.

1.3 PURPOSE AND RATIONALE FOR CAPACITY BUILDING

The purpose of this capacity building was to obtain practical knowledge in assessing PPD in fresh cassava, application of technologies for enhancing shelf-life of FCR and also to appreciate



the market context within which these technologies have been made financially and economically viable. Specifically participants acquired knowledge and skills in the following:

- 1) What varietal and ecological factors influence shelf-life of FCR and how varietal selection for PPD and waxing/relative humidity storage is carried out
- 2) Agronomic and pre-harvest practices that reduce PPD in FCR while increasing yields of cassava
- 3) Harvest practices used to ensure reduced PPD and extended shelf life of cassava roots
- 4) How to assess and score PPD and to analyse for other root characteristics as they change with storage time
- 5) Laboratory techniques and equipment used in PPD assessment
- 6) The best packaging and handling methods used to transport FCR to the pack house for waxing and also ensure waxed/RH root quality is assured during marketing, especially over long distances
- 7) Best practices and techniques used in application of both waxing and RH storage treatment at the pack house facility
- 8) What sensory and consumer attributes are scored for the waxed/RH roots
- 9) How value chains are organized and managed at the different levels
- 10) What marketing models are currently in use, including market segments, pricing and demand promotion/creation
- 11) What marketing challenges are faced and how they are overcome
- 12) How gender was incorporated in the value chains
- 13) Knowledge and information on setting up and operating a pack house

1.4 OUTPUTS

This training generate information and knowledge about setting up and commercializing a pack house for extending the shelf-life of FCR via use of waxing and relative humidity technologies. Specifically the capacities of the Uganda cassava team were strengthened in the following areas:

- 1) Conducting varietal selection for waxing and RH storage
- 2) PPD evaluation, root waxing and relative humidity storage treatments
- 3) Agronomic practices in terms of land preparation, ridging, planting techniques for increasing yields of commercial roots suitable for waxing and relative humidity storage
- 4) Pruning and its effects and implications for extending the shelf-life and eating quality of cassava roots
- 5) Designing, implementing and facilitating inclusive FCR value chains
- 6) Product development targeting different market segments for FCR
- 7) Designing, setting up or adapting commercial pack houses for waxed and relative humidity cassava roots
- 8) Trader-based model for operating a pack house for waxed and relative humidity roots.

This report details the approach, activities, achievements, knowledge gained and lesson learned from this capacity building.

2. Capacity building approach

A capacity building programme was jointly developed by IITA, CIAT and CIRAD. This required seven members of the Uganda research team to travel to Colombia since it hosts the CIAT Headquarters and it is one of the countries where both waxing and RH treatment of fresh cassava roots are already in commercial use. The approach involved laboratory analyses, field visits and use of secondary data (see annex 1). Specifically this included the following:



- 1) Practical sessions for assessing PPD and conducting other laboratory analyses for parameters such as dry matter content (DMC)
- 2) Field visit to expose the Uganda research team to agronomic practices, waxing and RH applications, management of pack houses and market innovations currently in use in Latin America
- 3) A rapid market reconnaissance interacting with actors along the value chain
- 4) Knowledge sharing sessions at the CIAT Headquarters.

The Ugandan research team comprised participants from all the implementing partners in Uganda, i.e., NARO, IITA and IIRR (Annex 3). The visit to Colombia took place over the period 30 May 2015 to 11 June 2015.

The research team had hands-on experience in harvesting and preparing fresh cassava roots for PPD scoring and lab analysis. This cassava subproject is about testing and validating the two proposed shelf-life extension technologies in Uganda. These technologies are new in Uganda. Apart from understanding their efficacy, it was imperative for the team to analyze their financial viability. Therefore the research team included socio-economists, an engineer, and crop and postharvest scientists from the three implementing partners. The exercise was supervised and guided by CIAT and CIRAD scientists.

Visits were carried out covering the entire value chain from production/supply areas to packaging/waxing facility and thereafter to market outlets. Along the chain, the team engaged actors seeking answers to specific questions (see section 1.3 above). Brainstorming and discussions with actors along the value chain plus observations of practices were the main methods for gathering information. Aspects of the Participatory Market Chain Approach (PMCA) were used during the rapid market assessment of the value chain in Colombia. Phase one of PMCA aims to provide information about actors along the value chain including their practices and relationships. PMCA tools for rapid market appraisal and quantitative market study were handy in enabling the research team to quickly assess and understand the market conditions for waxed and RH cassava roots. Although all aspects were jointly carried out in a participatory manner, NARO took the lead in assessing PPD, the IITA engineer took lead in assessing pack house facilities while the socio-economists guided collection of data on value chains and marketing aspects.

Areas visited included the following:

1. Cassava farms in the supply area of Granada
2. A pack house (waxing and RH treatment) in Granada
3. A processing facility in Bogota City for peeled and packaged fresh cassava roots, pre-cooked cassava roots, cassava crockets and baked cassava products.
4. A retail outlet in Bogota (major supermarket)

3. Major activities and events

3.1 VISIT TO CIAT CASSAVA PROGRAMME

On day one, the Ugandan research team met with the CIAT cassava team that included the Programme Leader, a breeder and other scientists. Annex 3 shows participants at this initial meeting. The CIAT scientists gave a brief on the focus of the cassava breeding and postharvest research at CIAT. They also highlighted how research was contributing to the development of the cassava value chain in Colombia and how research outputs were being accessed and



utilized by the private sector. In addition, the team gave a brief on the challenge of PPD and how it was being addressed including current success stories. An insight was given on the agronomical practices that promote shelf-life extension of the roots. This meeting also discussed the proposed capacity building programme, including all field and lab operations that had been planned for.

3.1.1 Breeding aspects for cassava

Targeted breeding for varieties with good postharvest traits have been carried out for the Colombian market. These include varieties with straight and not too long roots that are easy for packaging, roots with a peduncle to reduce chances of damage occurring during the harvesting process (peduncle should not be too long, otherwise root losses at harvest increase), and varieties with adequate dry matter and low cyanide content for the fresh market. Similarly to Uganda, the breeding programme has focused on generating high yielding and disease resistant varieties. However, the programme in CIAT has also targeted the problem of PPD. An interesting goal has been the development of varieties for table consumption which are also nutritionally enhanced through the increased levels of carotenoids (biofortified cassava) which also have delayed PPD. The programme has mainly worked with farmers. A new focus for the programme is breeding for industrial purposes, having successfully increased the yield and resistance in cassava varieties to enhance food security. Industrial varieties require maximum levels of dry matter content and are usually bitter (i.e., have high cyanide content). Recently work targeting the starch industry began with the development of commercial cassava varieties carrying the amylose-free starch mutation which was identified in 2006. On-going work is now searching for other types of starch, particularly the high amylose trait which is desirable for people suffering from diabetes.

3.2 FIELD OBSERVATIONS OF CASSAVA AGRONOMIC AND POSTHARVEST PRACTICES

3.2.1 Agronomic and pre-harvest practices

In Colombia the Ugandan team was introduced to the different cassava agronomic and pre-harvest practices that influence the effectiveness of waxing and RH technologies.

Cassava stems are first treated with a fungicide and root stimulating hormones before planting. Cassava is planted in ridges that are made by a tractor. Planting is done by hand at a spacing of 60 cm between plants and 1.8 meters between ridges. Planting in ridges maximizes yields, eases the process of management, weeding and also helps reduce physical damage to the roots during harvesting. Planting is done in such a manner that the side of the material with the largest number of nodes faces upwards. Planting material also points in the same direction in a horizontal manner. The implication of this is that roots sprout from one side of the stem in the whole field. It also assists in harvesting as 99% of the roots can easily be predicted in terms of location. Fertilizer is applied to the side where most roots (60% or more) will sprout. It involves phosphorus, potassium, zinc and magnesium at 20, 60 and 90 days of planting.

Stems are planted in a horizontal manner in order to allow for growth of a longer peduncle. Roots are also harvested in such a way that the long peduncle is retained. This is important in reducing the on-set of PPD since it gives more protection to the harvested roots. Such roots are suitable for waxing and relative humidity treatment. Planting stems in a vertical way results in short peduncles. In Colombia yields are up to 39 tons per hectare.



Pruning is an important agronomic practice both for waxing and RH treatment. It is done 6 days prior to harvesting. It involves the removal of the leafy tips of the cassava stems on all plants. The upper parts of the branches are removed. Roots are then harvested on the seventh day. Pruning releases sugars and thereby making the roots sweeter. In addition it provides protection from PPD by assisting the curing and hardening of the roots.

3.2.2 Harvesting and postharvest handling

Roots are harvested when plants are between 8 and 12 months old. This is when yields are highest. Extensive care is taken during harvesting to avoid any breakage or physical damage to the roots. An innovative manual harvester is used. Harvesting is easier when the soils are moist. Since planting is done in ridges, the roots can easily be pulled out by hand in wet conditions. A machete (panga) or “secateurs” is used to carefully detach the roots from the stem, leaving a reasonably large piece of the peduncle on the root. Due to this, the parenchyma is not exposed to air.

Roots are selected and graded into three categories A, B, and C. Category A consists of roots classified as commercial with no damage. They are immediately placed in crates and transported to the packing facility for waxing and relative humidity storage. Category B comprises commercial roots that have been damaged and hence becoming unsuitable for waxing and relative humidity storage. These roots are fewer than category A since considerable care is taken to avoid any mechanical damage. Category C comprises non-commercial roots, that are much smaller. Roots in both categories B and C are packed and tied in high density polyethylene bags weighing 30 kg each. They are sold either as fresh in open markets or processed into other products. Packed bags of cassava are shown in annexes where they are being off loaded in Bogota at a fresh root processing plant.

3.3 CIAT CASSAVA GERmplasm CENTRE

CIAT Colombia has over 68,000 varieties of cassava preserved *in vitro* with 160 countries benefiting from their germplasm. Collection of wild cassava from the Amazonia is carried out. Cassava originated from Colombia and the first obligation is to conserve all cassava germplasm and keep it in the form it is collected. It is conserved *in vitro* to reduce disease spread. Germplasm for rice, beans, forages and various trees is also collected and preserved.

Research on slow growth *in vitro* preservation of materials is being conducted. The slow growth *in vitro* technique has enabled specimen to be kept without replacement for 30 instead of 12 months. Research on cleaning of viruses by using cryotechnologies is also being carried out. In addition, searching for genetic duplication in the cassava collection and better ways of managing is being done.

3.4 THE CLAYUCA HIGH QUALITY CASSAVA PROCESSING PLANT AT CIAT

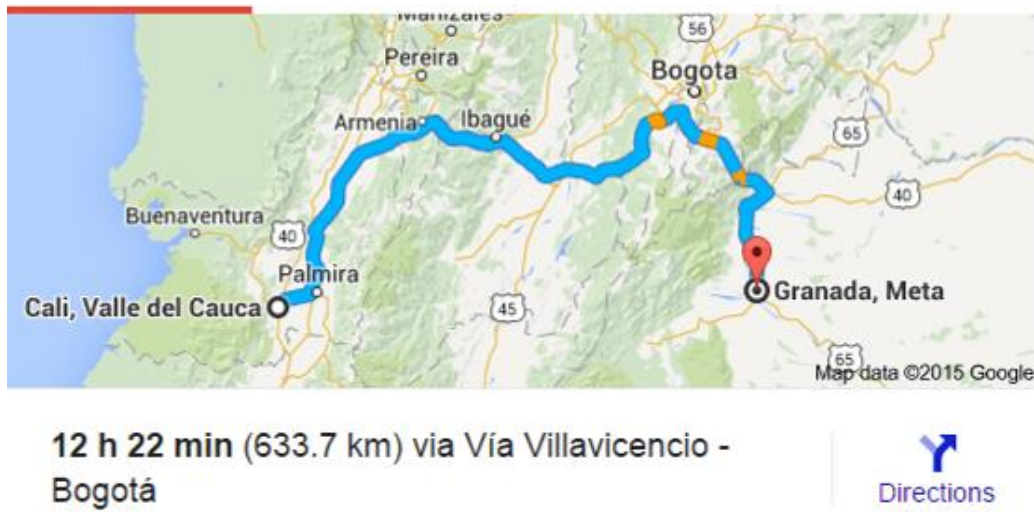
The team visited the CLAYUCA high quality cassava processing plant at CIAT. It is a state of the art facility involving new innovations that eliminate the need for manual peeling. The process automatically removes and separates the peels from the final product, which is high quality cassava flour. Labor costs are increasing in many countries due to the shortage of labor. It can process 5 tons of cassava per batch producing 1 ton of flour. The facility also has an in-built drier. Drying takes 8 hours and uses gas. This plant costs US \$ 80,000. It can potentially be adopted in Uganda.



3.5 ORGANIZATION OF THE FRESH CASSAVA ROOTS VALUE CHAIN IN COLOMBIA

Ugandan researchers were exposed to the entire value chain of fresh cassava in Colombia that included farms/supply areas and a pack house in Granada, and a processing facility and a retail outlet in Bogota. From the farms, some cassava roots are transported directly to the processing facility in Bogota while other roots are sent to the packing house for waxing and relative humidity treatments.

Figure 1: Supply and consumption areas visited



3.5.1 Supply farms

The team visited a prominent cassava farmer in Granada (634 Kms from Cali). It also visited five estate cassava farms owned by Agrollanos Limited. The company has over 1000 acres of cassava in Granada, spread out in different locations. Cassava is planted in ridges and this eases the process of harvesting. Operations are mechanized and most of the work is done by tractors. Fertilizer application is carried out. Phosphorus is applied after 15 days of planting. Later zinc and phosphate are applied. Roots reach maturity after 12 months of planting. Fresh roots are harvested on the seventh day after being pruned. They are carefully uprooted by hand to minimize damages. Separation of the roots from the stem is carefully carried out, cutting the peduncle at the point where it is attached to the stem. In this way, the roots come with a long peduncle that protects them from injury. Undamaged roots of good size intended for waxing and relative humidity storage are carefully selected from roots that are smaller and/or of a poor quality.

3.5.2 Transportation

The roots meant for waxing and relative humidity are carefully placed in crates weighing about 20 kg. Care is taken to avoid placing too many roots in the crate in order to minimize bruising during transportation. These roots are transported by truck to the packing facility for further waxing and RH treatment. On the other hand, smaller roots and those that have been damaged are packed in semi-hermetic bags that weigh between 25 and 30 kg. They are directly transported by truck to the processing facility or to open markets mainly in Bogota.



3.5.3 Packing house

Two technologies for shelf-life extension are carried out at the packing house. They include waxing and relative humidity storage. These technologies do not improve the quality but rather aim at conserving the freshness of cassava roots and extending the shelf-life. They are therefore performed on roots presenting very good culinary qualities. The packing house has six workers.

Once the roots arrive at the packing facility, they are re-inspected. Roots showing signs of physiological and microbial deterioration are removed. Bruised, broken or damaged roots and those without the required commercial size and shape are discarded. This is conducted based on the specifications of different markets/consumer preferences. For instance, supermarkets require whole roots without any physical damage. Hard peduncles on the cassava root are cut off from both ends in preparation for washing, i.e., both the proximal and distal ends of the roots are carefully trimmed.

Water of portable quality is used to wash the roots. Superficial soil and dirt is removed by scrubbing the roots using a brush with soft plastic bristles to avoid damaging the peel. Washing is done in two steps. The first washing is performed using a soft bristle brush to remove any external/foreign matter like dust, sand, and any other contaminants. The second stage is to final wash/inspect in another tank filled with fresh water. Washed roots are submitted to a second quality control check to discard any roots found unsuitable that may have been missed during the first quality control check. Roots are checked for signs of deterioration. Stumps and peduncles are adjusted while parts of the epidermis that have been detached are removed. Care is taken to avoid damaging the root at this stage. After the two rounds of washing, cassava roots are carefully packed in plastic crates weighing 20kg each. Water is allowed to drip from the roots in the crates for about 20 minutes.

After draining, the roots are dipped for about two minutes in a cold solution containing a fungicide (Mertec), a surfactant/adhesive (Pegal coadyuvante Agricola) and water. The mixing ratio for the fungicide is 1ml per litre of water while that for the surfactant/adhesive is also 1ml per litre of water. The adhesive assists the fungicide to bind on the cassava root.

3.5.3.1 Relative humidity storage

After the washing and disinfection process, roots are straight away placed in clean green semi-hermetic bags and sealed. This is done while the roots are still wet or moist. The sealed bags are then placed in crates ready for transportation and eventual distribution to urban supermarkets. Each crate weighs about 20 kg and sealed. These roots have an extended shelf-life of between 10 and 12 days and are sold to supermarkets, restaurants and sometimes directly to households. The cost of green bags used for packaging is estimated to be USD 40 for 1,000 pieces.

3.5.3.2 Wax treatment

In the case of waxing, cassava roots are left to dry under the shade following the washing and the disinfection process as earlier explained above. Cassava roots are spread out on a raised platform with wire gauze that allows warm air to circulate around the root under a shade. Wax treatment requires that the root surface is completely dry. Complete drying takes place in about two hours.

Finer food grade paraffin wax is used. It adheres better to the peel and improves the appearance of the root. The wax is heated in a rectangular stainless steel tank (600mm x 400mm x 450mm deep) into a thin colorless liquid at a temperature of 140°C - 160°C. This tank



(heating container) holds about 40 kg of wax. This quantity can wax up to 200 crates of cassava. The wax costs about USD 40 per 50 kg bag. The wax used is clear and it is easily obtained in Uganda. The team obtained samples of the bags and information on the type of wax used to help in planning for procurement of similar materials.

Dry roots are then submerged in the heated wax. A special basket fabricated for easy immersion of cassava roots is used. This basket is made from stainless steel. Cassava roots are placed into this basket that has cylindrical handles. The basket is then lowered into the heated paraffin liquid. Complete immersion time is less than two seconds to prevent cooking of the cassava roots due to the high temperature of the liquid. If the temperature is below 140°C, the root is covered with a very thick layer of dull looking wax. Above 160°C, wax evaporates hence its consumption increases and the roots could even get boiled. Therefore, a thermometer is needed to check the temperature of the wax during heating. The source of heat can either be gas, firewood or electricity. In this case liquid petroleum gas (LPG) was being used.

After waxing, cassava roots are cooled for about one minute. The waxed roots, that have a shelf-life of about two months, are then placed in crates weighing 20kg ready for transportation to supermarkets in Bogota.

Figure 2: Waxed cassava in supermarket



3.5.4 BOGOTA processing chain plant

The processing plant in Bogota known as Agrollanos was also visited. The facility processes 25 tons of cassava roots per day. It only receives smaller/lower quality roots that are not suitable for either waxing or relative humidity storage. The processing facility in Bogota employs about 80 laborers, majority (80%) being women. This facility processes a number of products that include peeled and frozen roots; and peeled, half-cooked and frozen roots. The company also dry and sell cassava peels to animal feed manufacturers in Bogota. Peelers are paid 120 pesos per kg (2,300 Pesos is equivalent to 1 US dollar).



3.5.4.1 Semi-cooked cassava product

One of the products is semi-cooked frozen cassava. Roots are received directly from the farm. These fresh roots are peeled, precooked for about 10 minutes and then frozen. This cassava is usually fried and sold as a snack as shown in Annex 6.

3.5.4.2 Fresh cassava product

Here the roots are peeled, washed and then soaked in a solution of 1 ml/litre of hypochlorite, Dioxixan (1ml per litre) and 1g/litre of citric acid prior to packaging. They are then chilled and sold to supermarkets, restaurants and households (Annex 6).

3.5.4.3 Cassava crockets

Peeled fresh cassava is boiled, mashed and made into different cassava crockets and snacks. The crockets and snacks are pre-cooked and rapidly frozen in order to save on the time of preparation as well as extend their shelf life as shown in Figure 3. This product is sold to consumers through supermarkets and restaurants.

Figure 3: Peeled fresh cassava at a supermarket stall in Bogota



3.5.4.4 Baked products

Cassava flour can be used as partial substitute of wheat flour in several bakery products. Partial usage of cassava flour can provide bread with high fiber content (having cassava flour higher fiber content than wheat flour) and that is desired for good health and nutrition. Products that are being made from the cassava-wheat composite flour include bread rolls, sandwiches and hamburger breads.

3.5.4.5 Animal feeds

The peels are dried for three days using a solar drier at another plant, packed and sold to an animal feed manufactures where they are mixed with soya meal and maize bran. The plant sells the cassava peel powder at 500 Pesos per Kg (USD 0.22).



3.6 MARKETING

All the products are locally marketed by the company with the main market being Bogota, the capital city. Apart from this, other markets exist within Colombia. The retail price of waxed cassava was 2,800 Pesos per Kg (USD 1.02) in Bogota while relative humidity stored cassava was priced at Pesos 2,180 per Kg (USD 0.92).

3.7 VARIETAL ASSESSMENT

3.7.1 Assessment of PPD

Six varieties were scored and assessed for PPD with each variety comprising of two different samples (one pruned and one unpruned). The roots were carefully harvested to avoid any damage and transported to CIAT facilities immediately. The process of PPD assessment took seven days. The following varieties were tested for PPD:

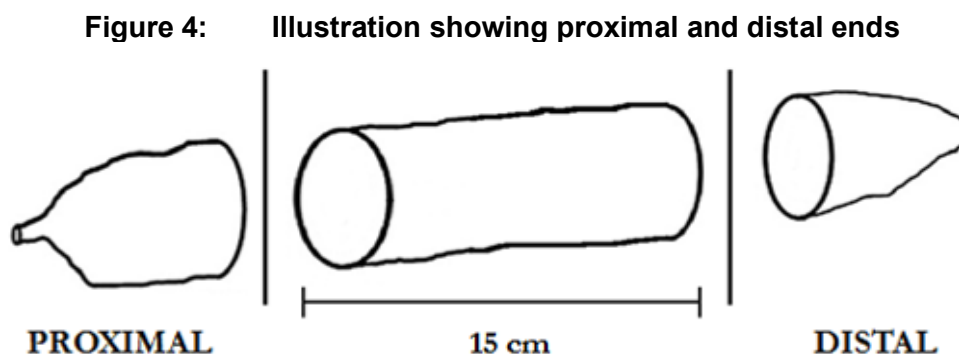
1. HMC-1
2. GM 3916-8
3. GM3518-26
4. MCOLL-22
5. CM 523-7
6. MPER-183

Materials used included the following:

1. PVC film (polyvinyl chloride plastic)
2. Scissors
3. Knife
4. Cutting board
5. Rubber bands
6. Paper towels

Methodology for PPD assessment

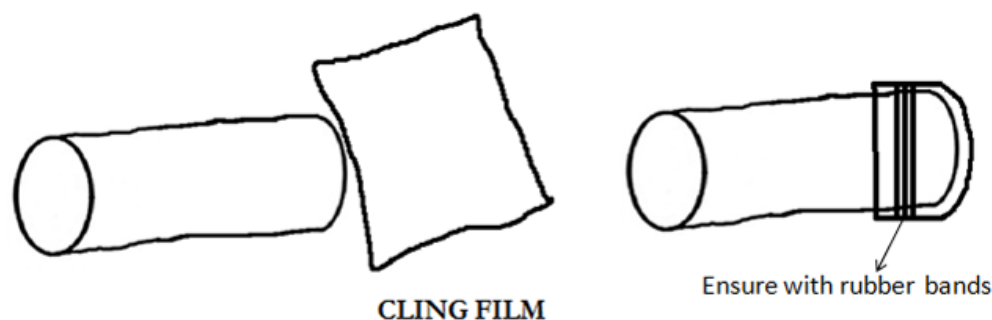
1. Ten commercial roots of each variety are selected with a minimum size of at least 18 cm. Only roots without mechanical damage are chosen.
2. The distal and proximal ends of the roots are discarded by cutting them with a knife, so that the remaining root section is about 15cms long.





3. The distal side is covered with a PVC film to keep the moisture. This is also important to prevent physiological deterioration because it always starts from this surface, and force that develops physiological deterioration from the proximal end.

Figure 5: Illustration for covering proximal ends



4. The roots are then stored in an outdoor place but protected from sun and rain.
5. Evaluation is done after seven days of storage. Roots with microbial contamination are discarded. The evaluation implies the following steps:
 - a. Each root is cut crosswise into sections at 2, 4, 6, 8, 10, 12, and 14 cm from the proximal end. After each cut the knife has to be cleaned or otherwise a stainless steel knife has to be used. A total of 7 sections are evaluated.
 - b. Numerical values are assigned according to a scale of 0 to 10 on the proximal surface of each cut. The scale values corresponded to the following:

0 to 0%	6 to 60%
1 to 10%	7 to 70%
2 to 20%	8 to 80%
3 to 30%	9 to 90%
4 to 40%	10 to 100%
5 to 50%	

Figure 6: PPD scores



6. The average of the 7 scores is then calculated and represents the “percentage of deterioration” (Wheatley et al., 1985). The maximum possible value is 70 (i.e., all 7 sections showing 100% deterioration).

Figure 7: PPD assessment on one cassava variety at CIAT





3.7.2 Analysis of scopoletin

During PPD, several biochemical compounds are produced as secondary metabolites in response to physiological stress resulting from injury to the cassava fresh roots. Scopoletin is one of the main compounds in addition to other carbon based ones such as the coumarins and non-structural proteins. The accumulation of scopoletin defines the extent of tolerance of a particular variety to PPD.

Steps for analysis of scopoletin included the following:

- 1) An extract of mashed cassava sample is obtained
- 2) 5mls of ethanol (90%) is added and vortexed for one minute
- 3) The extract is then centrifuged at 10,000 rpm for five minutes
- 4) A supernatant is extracted and the process is replicated three times.

3.7.3 Assessment of dry matter content

The other process learnt during laboratory experiments is the assessment of dry matter content. Samples are put on petri dishes and weighed (weight is recorded before and after drying for 12 hours). They are oven dried at 105 °C.

4. Lessons learnt

The technologies that the project intends to introduce to Ugandan actors are generally new. However, they are already in commercial use elsewhere such as in Latin America where there is a similar problem of PPD. Therefore, there was an urgent need to expose the Ugandan research team on how these technologies are being used in Colombia, the context within which they are used and the drivers and major characteristics of their fresh root value chain. A number of lessons in this regard were learned.

4.1 LABORATORY BASED TRAINING ON ASSESSING PPD AND OTHER SHELF LIFE QUALITIES OF CASSAVA

The team was exposed to a number of procedures for the assessment of PPD in cassava. The procedures, which include the scoring of roots after seven days are a modification from what is currently used for studies on cassava PPD in Uganda. The modification includes the use of a shade where temperature and relative humidity are controlled and their effects on the experiment determined. In addition to High Performance Liquid Chromatography (HPLC), analysis of biochemical compounds resulting from PPD (e.g., scopoletin) is used. It is worth to point out that the visit allowed the Ugandan team to realize that such a capacity well exists in Uganda and can be further improved by putting in place the following:

1. A shade designed in such a way as to avoid direct sunlight and increase air flow
2. Comprehensive sample preparation to allow for uniformity: need for a sample preparation machine especially for samples undergoing dry matter determination and analysis of biochemical compounds by HPLC. These include starch content, scopoletin, proteins, amino acids and secondary metabolites.
3. Use of Near Infra-Red Spectroscopy (NIRS) technology is key in analyzing large sample loads with precision and therefore this would also be necessary to carry out at the laboratory at NaCRRRI
4. Modification of harvesting procedures to reduce mechanical damage of the roots.



4.2 AGRONOMIC AND PRE-HARVEST PRACTICES

For both waxing and RH technologies it to be effective there is need to change agronomic and pre-harvesting practices. Pruning was found to be a major practice that influenced or assisted in the efficacy of waxing and RH in extending the shelf-life. PPD was slower in pruned cassava than in cassava that did not undergo any pruning.

Pruning also enhanced the taste of roots. In fact it has the effect of increasing the conversion of starch into sugars and hence makes the roots sweeter. While this may not be deliverable in countries where cassava is primarily used for starch extraction, it can improve the marketability of cassava in countries where it is often consumed in fresh form, such as in Uganda. Pruning also hardens the roots, which helps reducing injury during harvesting and postharvest handling.

In Colombia, cassava is planted in ridges. Technologies for extending the shelf-life work best for roots that have not been damaged during harvesting. It was also noticed that not all the roots are suitable for waxing and RH. Only fully grown undamaged roots of a good size and shape are singled out. Planting in ridges was found to ease the management of the gardens thereby improving yields and root growth. It also aids the process of harvesting (reducing drudgery) and minimizes damage to roots. It was also learned that there is a planting technique that promotes longer peduncles in cassava roots.

4.3 PACKAGING AND TRANSPORTATION

Packaging was found to be carefully done in order to minimize the damage of roots whose shelf-life is to be extended. Crates are used to transport such roots. The packaging is done carefully avoiding placing too many roots to minimize bruising. This is not the case of Uganda where the main aim is to maximize the weight of each bag in order to reduce the cost of transport since transporters charge by bag and not by weight. The weight of cassava bags in Uganda varies by area. While its not yet clear what the actual weight is in the various areas, it is estimated that this usually ranges between 150 and 200Kg but it can be higher in major supply areas such as Kiryandongo.

4.4 PACKING HOUSE

This comprised simple materials and equipment. The lay out was also simple comprising a shade of about 9 by 18 meters. The equipment and materials used included knives, buckets, and crates. It is estimated that 16.5 grams of wax is used to wax 1 kg of cassava root and the cost of the wax is USD 0.8 per Kg.

A list of the required materials and graphical representations of the equipment and structures required for a pack house are reported in the following pages.

Table 1: Materials for building of waxing center



NO	DESCRIPTION	QTY
1	BAMBOO	35
2	ROPE	2 COILS
3	GALVANISED ROOFING SHEETS	5 BUNDLES (100 sheets)
4	NAILS	900
5	WOODEN PALLETS	120
6	RECTANGULAR PLASTIC CONTAINER ²	350

Table 2: Materials for building of warm air drying shed

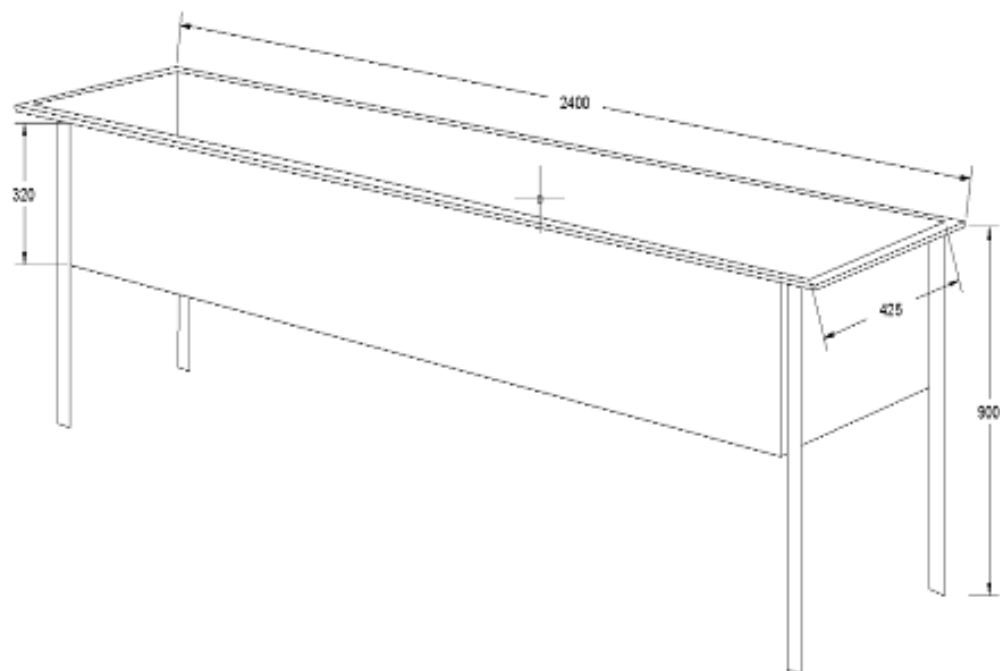
NO	DESCRIPTION	QTY
1	BAMBOO	25
2	ROPE	2 COILS
3	THICK NYLON SHEETS	-
4	GALVANISED WIRE SHEET (ROLLS)	-

Table 3: Basic requirements for pre washing handling

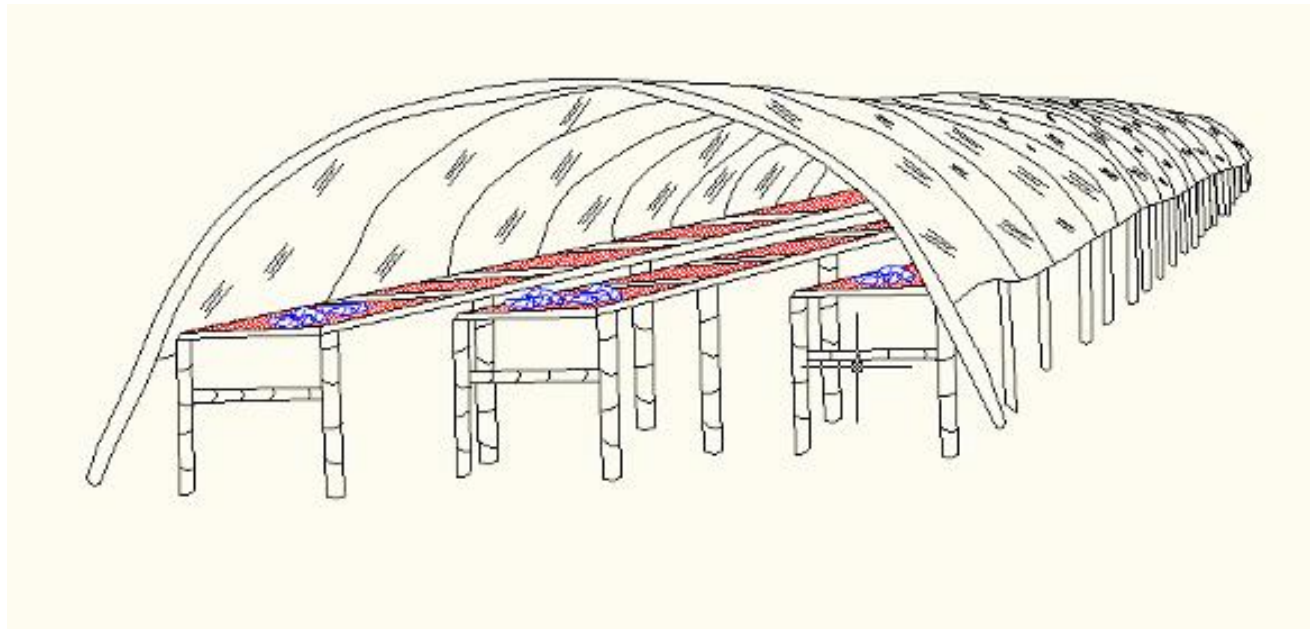
NO	DESCRIPTION	QTY
1	SECATEUR OR SHARP KNIFE	6
2	SEMI HARD BRISTLE BRUSH	6
3	WATER SUPPLY BORE HOLE, WITH OVERHEAD TANK	1

Table 4: Tools and equipment needed for waxing

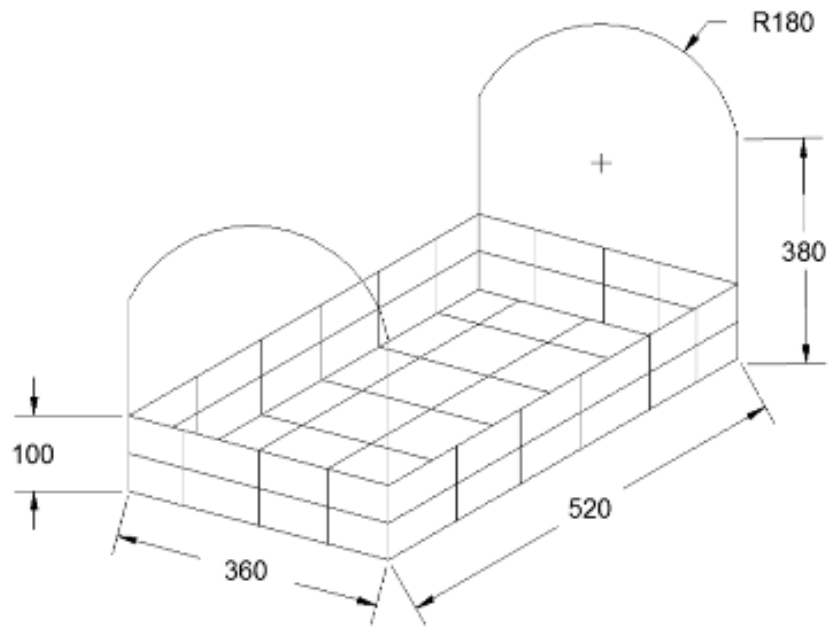
NO	DESCRIPTION	QTY
1	WASHING PLASTICS	6
2	WASHING PLASTIC STAND	6
3	STAINLESS STEEL TREATMENT BAY	1
4	MILD STEEL PRE WAX STAND	1
5	STAINLESS STEEL WAXING POT	1
6	GAS UNIT	1
7	GAS BURNER	1
8	MILD STEEL POST WAX COOLING STAND	1



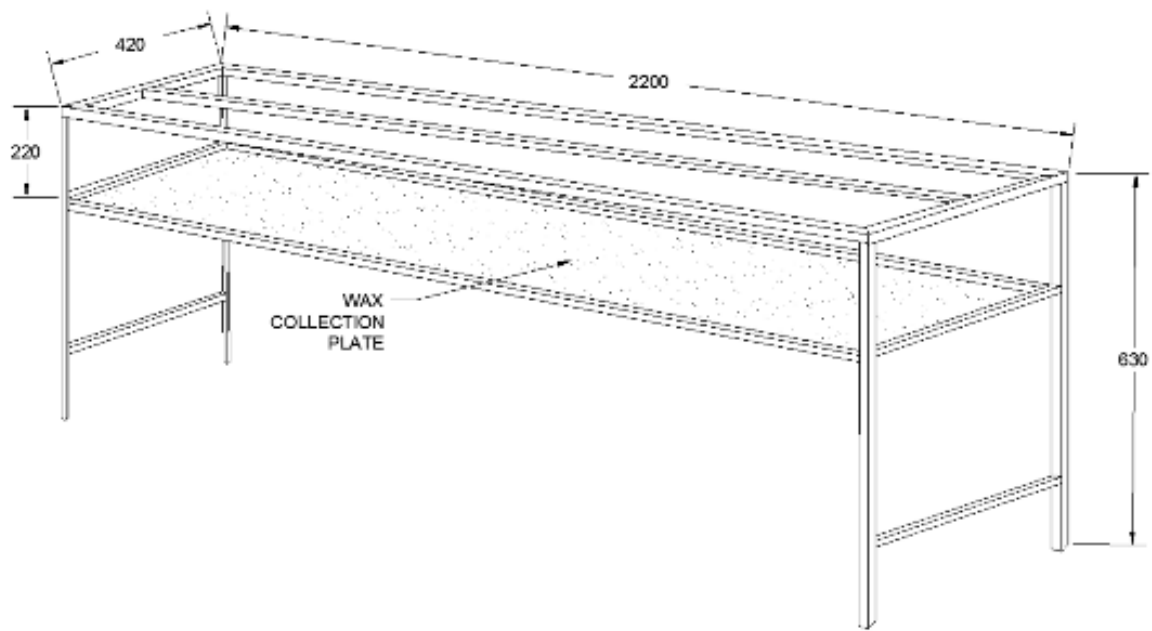
FUNGICIDE MIXING TANK



WARM AIR DRYING SHED FOR WAXED CASSAVA ROOT. 6M x 20M



DIPPING BASKET FOR CASSAVA WAXING



PRE/POST WAXING STAND



4.5 LOCATION

It is evident that waxed cassava roots can be transported over very long distances. In the case of Colombia, the packing facility for waxing and relative humidity storage is situated over 600 km from the main marketing point in Bogota. In addition, it is not in a major cassava production area but rather a livestock production dominated area. This is so because the waxed cassava market is a niche market that did not require huge volumes and fresh cassava are mainly sourced from farms owned by the company.

4.6 ENTREPRENEURSHIP

This is very critical for business start-up and growth. The entrepreneur in Colombia did not have any support from the national research organizations. However, he had very good collaboration with CIAT from where he accessed the technologies. He took the initiative to seek information and knowledge, and piloted whatever he read about. He continued to work to grow his business. It was his zeal and business acumen that provided the engine of growth and development of the value chain.

4.7 ORGANIZATION OF THE VALUE CHAIN

It was evident that the value chain in Colombia is efficiently organized. It is effective in terms of delivering a quality product. Activities are very well integrated along the value chain right from production (use of good farming practices) through processing, handling and retailing.

The model is private sector driven relying on a single entrepreneur who is the major driving force. He plays a key role of champion, renting land, investing in capacity building activities of his labor force and also running the packing and processing facility on very sound business principles. The lesson learned in this regard is that strengthening entrepreneurial skills would be important if Uganda is to pilot a similar model successfully. Moreover, a private sector trader led model has the potential to reach more smallholder suppliers than a farmer led approach since smallholders tend to have access to less resources to invest (including credit) and also often lack the required commercial orientation.

4.8 MARKETING

Supermarket is the main marketing channel for waxed and RH cassava roots. Waxed cassava is a smaller niche market compared to unwaxed cassava. The processing facility manufactures several cassava products such as pre-cooked and frozen cassava roots.

5. Way forward

There is a strong linkage between postharvest shelf-life extension technologies that the RTB-ENDURE project intends to test and validate in Uganda and the required agronomic practices, all this being new in this country. On the other hand, this is a short research project that aims at understanding how these new technologies can be adopted and adapted to the Ugandan context. Despite the substantial effort to impart as much as possible to the Ugandan researchers the visit to LA was short. It would therefore be important to continue exploring ways and means of deepening the collaboration and sharing information between Colombian private sector, CIAT and Ugandan implementing partners. Alongside this aspect, it was agreed to explore seeking more research funds to support further capacity strengthening activities and South-South collaboration.



5.1 RELEVANCE OF SOUTH-SOUTH COOPERATION

This is a research project. While waxing and relative humidity technologies are relatively new in Uganda, they are already in commercial use in Latin America. The fresh value chain in Colombia is more developed and well integrated. Valuable information and knowledge was obtained from the visit and interactions with CIAT/CIRAD staff, farmers and private sector actors. There is need to maintain and strengthen this collaboration. Areas of collaboration are likely to include breeding for varieties in respect of PPD and the different cassava market segments, germplasm exchange, protocol development, management of emerging viral diseases such as frog skin disease in South America and cassava brown streak disease and cassava mosaic disease in sub-Saharan Africa. Unlike the North-South exchanges which are sometimes too focused on theory, South-South collaboration provides cassava partners in SSA with both theoretical and practical experiences since cassava is a major source of livelihood in both regions and substantial research has been conducted over the years in Latin America.

5.2 RELEVANCE TO NATIONAL CROPS RESOURCES RESEARCH INSTITUTE (NACRRI)

NaCRRRI is a renowned centre for research and development for a number of crops in Uganda. The institute is home to the cassava Regional Centre of Excellence for East and Central Africa and it leads a number of initiatives aimed at addressing regional problems especially in the areas of breeding and pests and diseases management. The Centre however has not embarked on a number of relevant aspects of R&D for improving and sustaining the cassava value chain. From this visit, it is expected that a number of initiatives will be followed up with the support of CIAT/CIRAD in the areas of breeding for farmer preferred traits, industrial traits, nutritional enhancement and development of higher value cassava products.

In addition, lessons learnt regarding the various agronomic practices that influence waxing and RH treatment will be evaluated and shared widely. Further research will be conducted to deepen their understanding and so as to strengthen the fresh cassava value chain. Practices such as planting in ridges, pruning, varietal selection and fertilizer application need thorough analysis in terms of their costs and benefit to users. They need to be tested and re-tested to determine optimal conditions necessary for their efficacy in extending cassava shelf-life.

This visit provided a unique opportunity to share knowledge about future research and areas of possible collaboration. Areas of collaboration include knowledge sharing on laboratory protocols, equipment use and maintenance, agronomic practices and product development.

6. Conclusion

The capacities strengthening programme organized in collaboration with CIAT/CIRAD was fruitful. It has provided an opportunity to the Ugandan cassava research team to get first-hand information about the new technologies that will be tested in Uganda. The visit also provided an opportunity to understand the different contexts and similarities existing between Colombia and Uganda. We intend to put the substantial knowledge that was gained into immediate use for improving the performance of the RTB-ENDURE cassava sub-project and increase the likelihood to benefit the different actors in the cassava value chain in Uganda.



ANNEXES

ANNEX 1. CAPACITY BUILDING PROGRAM

Date	Topic/Activity	Responsible
June 1	CIAT campus visit to cassava programme Harvesting pruned and unpruned cassava and preparation of samples	Dominique and team
June 2	Visit to cassava germplasm - Transfer to Grenada	Elias, Gorge, Luna and Monica
June 3	Agrollanos visit of field and waxing/RH plant AGROLLANOS AGRÍCOLA DEL LLANO LTDA. CI 52 B S 27-27 Bogotá, Colombia. Tel: (57) (1) 7132972	Elias, Gorge, Luna and Monica
June 4	Transfer to Bogota	Luna
June 5	Visiting processing facilities in Bogota Visit cassava marketing and storage facilities in Bogota	Elias, Gorge, Luna
June 6	Visit supermarkets -Transfer to Cali	Elias, Gorge, Luna
June 7	Day of rest	
June 8	PPD scoring and preparation of samples for scopoletin and dry matter determination	Luna
June 9	Scopoletin sample injection by HPLC - Debriefing	Luna, Dominique

ANNEX 2. LIST OF PARTICIPANTS

Participant	Institution	Activity/Role
1 Clair Hershey	CIAT	Technical backstopping/Trainer
2 Dominique Dufour	CIAT/CIRAD	Technical backstopping/Trainer
3 Hernan Ceballos	CIAT	Technical backstopping/Trainer
4 John Eiver Belalcazar	CIAT	Technical backstopping/Trainer
5 Bernado Ospina	CLAYUCA	Technical backstopping/Trainer
6 Jorge Luna	CIAT	Technical backstopping/Trainer
7 Monica Pizarro Sanchez	CIAT	Technical backstopping/Trainer
8 Elias Rico Oliveros	Agrollanos	Trainer
9 Luis Ariel Rico	Agrollanos	Trainer
10 Alvaro Eduardo Santos Rubio	Agrollanos	Trainer
11 Diego Marin	Agrollanos	Trainer
12 Bamidele Alenkhe	IITA	Trainee
13 Harriet Muyinza	NARO	Trainee
14 Moses Matovu	NARO	Trainee
15 Ephraim Nuwamanya	NARO	Trainee
16 Robert Kaliisa	IIRR	Trainee
17 Kelly Wanda	IITA	Trainee



ANNEX 3. PHOTOS



Plate 1: cassava harvester



Plate 2: Cassava at CIAT headquarters planted on ridges



Plate 3: Harvesting pruned cassava



Plate 4: Carefully harvested cassava for PPD assessment at CIAT



PPD assessment



Polyethylene sealing prior to storage



Learning team visiting farmer field



Sorted fresh cassava for waxing put in crates



Cassava packaging in polyethylene bags



Fresh cassava for processing Bogota



Participant washing fresh roots to be waxed



Mertect fungicide and Pegal adhesive used on the roots



Cassava roots dipped in fungicide



Relative humidity packaging of fresh cassava



Cassava roots being dried in a screen house before waxing



Cassava roots being dipped in wax



Cassava roots being dipped in wax



Waxed cassava roots weighed for packing in 20 kg packaging



Fresh roots delivered for processing at Agrollanos processing plant in Bogota



Fresh roots being peeled by workers at Agrollanos processing plant in Bogota



Peeled washed roots being washed at Agrollanos processing plant



Workers cleaning peeled roots ready for packing



Fresh Cassava roots



Peeling process



Weighing



Washing bag



Washing



Further cleaning



Clean roots



Roots in crates



Final rinse



Packaging

Cassava processing Technology



Frozen cassava roots



Refrigerated cassava roots



Cassava yorghurt



Deep fried cassava roots



Baked products from starch



Value added product from fresh cassava roots



Cassava in one of supermarket in Bogota



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