CASSAVA newsletter

Postharvest handling of cassava

Cassava as a crop is biologically very efficient in terms of producing carbohydrates on marginal soils in areas where rainfall is limited or uncertain. Over the last decade considerable research has been devoted to improving yields of cassava under these conditions with only limited use of purchased inputs. The result of this effort is new production technology that can dramatically increase cassava yields.

However, if farmers markedly raise their levels of production, they could run into many problems with marketing the extremely perishable cassava roots. Postharvest problems have then a critical importance; the decision of the Philippines Council of Agricultural Research and Resource Development (PCARRD) to give top priority to this area of research highlights this problem.

Postharvest research in cassava is divided into three main areas: fresh cassava storage, cassava drying, and development of new products. Work on fresh cassava storage has concentrated on determining the factors involved in the rapid deterioration of cassava roots and simple methods of preventing it. Cassava drying for animal feed is a well-established industry in Asia; in Latin America the Asian technology has been adapted to local conditions and is only now beginning to be used on a commercial basis. ▷

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The development of new products has recently received much more attention due to the increasing dependence of developing countries on imported cereal grains for such products as bread, noodles, and bakery products.

Considering the importance of postharvest handling of cassava, this edition of the **Cassava Newsletter** has been devoted to this topic.

James H. Cock

Aflatoxins in cassava ... is it a real problem?

C. Wheatley

Aflatoxins are a group of carcinogenic metabolites produced by some strains of the fungus *Aspergillus flavus*. Aflatoxin production is favored when this pathogen develops on plant tissues with a moisture content in equilibrium with an ambient RH of 85% and with a temperature range of 25-40°C. Under these conditions, present in the tropics and subtropics, agricultural produce such as rice, maize, peanuts, and others are easily infected.

As little as 1 µg/kg in the diet can produce liver tumors in rats. The aflatoxin intake of people in several surveyed regions of Kenya and Thailand is comparable to this figure; this intake has been associated with a higher incidence of liver cancer in these regions than in other of the same countries with lower aflatoxin contamination of the food supply.

Aflatoxins are therefore extremely potent toxic contaminants in the tropical environment. Several countries have placed limits on the amount of aflatoxin permitted in human food and animal feedstuffs (commonly 5-15 and 20-50 µg/kg, respectively).

Aflatoxins in cassava

Aspergillus flavus is a common postharvest contaminant of cassava; hence, the presence of aflatoxins in edible root tissues can be a serious problem.

There are several reports that indicate appreciable amounts of aflatoxins in both fresh and processed cassava, and that implicates contaminated cassava in the occurrence of liver cancer in the Philippines* and Uganda*. In the Philippine survey, 100% of the cassava samples analyzed contained aflatoxin, with a mean content of 468 µg/kg.

However, there is reason to believe that the apparent problem of aflatoxin contamination is not as serious as would appear at first; the high incidence reported is not always real and depends on the analytic methods used for aflatoxin determination.

The fluorescent characteristic of aflatoxins is the principal means of both qualitative and quantitative identification and determination. It is often the only method used after preliminary solvent extraction, separation, and TLC steps. Aflatoxins are characterized by a strong fluorescence when exposed to ultraviolet light; compounds B_1 and B_2 fluoresce blue and compounds G_1 and G_2 fluoresce green; B_1 is frequently considered the main aflatoxin present.

However, scopoletin, a coumarin involved in the rapid postharvest deterioration of cassava roots, also presents an intense blue fluorescence under ultraviolet light and shares similar Rf values with aflatoxin B_1 in some TLC systems.

Thus, it is relatively easy to confuse scopoletin with aflatoxin B_1, unless procedures specifically designed to eliminate the former interference are used,

(Continues on p. 14)

* Those interested in these reports can request their bibliographic citations from Dr. Christopher Wheatley, CIAT, Apartado 6713, Cali, Colombia

Postharvest deterioration of cassava roots

J. E. Rickard

The initial rapid deterioration of cassava roots after harvest appears to be essentially a nonpathological wound response, comparable with those observed in other plant storage organs. In cassava, however, the responses do not remain localized at the wound surfaces but spread down the roots causing a discoloration of the vascular tissue and storage parenchyma. These responses were found to be considerably affected by the humidity at which the roots were stored.

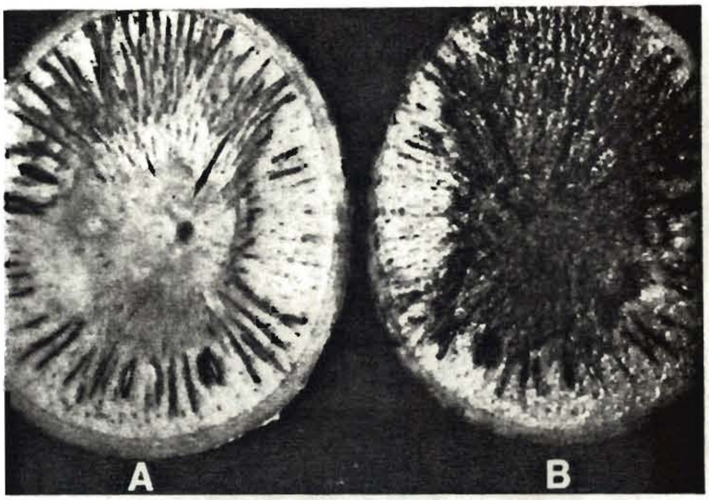

Figure 1. Discoloration of storage parenchyma associated with phenol production: a) deterioration symptoms; b) reaction of the discolored root to a phenolic compound indicator.

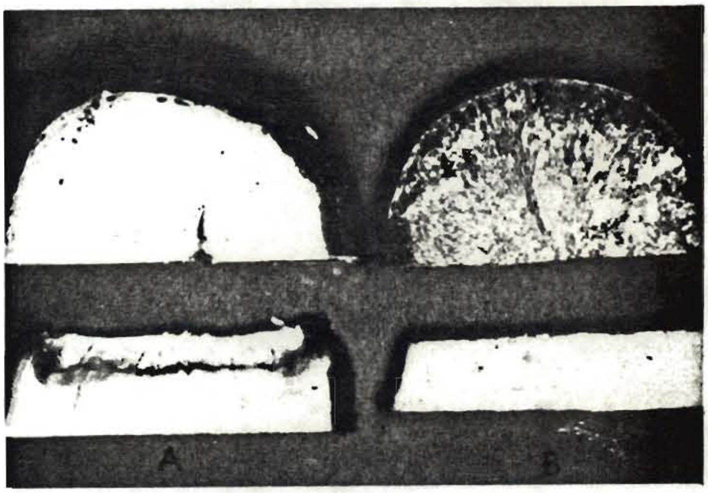

Figure 2. Samples of stored cassava. At low humidity (A), discoloration spreads rapidly in the parenchyma; at high humidity (B), a periderm is formed.

Causes of deterioration

Biochemical analysis showed that many changes in the phenolic constituents of the roots occurred following injury. Positive surface test responses on cut root pieces with vanillin, nitrous acid, and phloroglucinol-HC1 reagents also demonstrate the presence of phenols and lignin-like material in the discolored root (Figure 1).

A detailed cytochemical study of the colored deposits showed carbohydrates, lipids, and lignin-like material to be the major components and that these deposits were in close association with free phenols including leucoanthocyanidins and catechins. These changes at the wound surface were followed by the formation of a periderm in the roots held at high humidity (85-95% RH). A periderm was observed to develop transverse cuts within seven to nine days at 35°C and 10 to 14 days at 25°C (Figure 2), a time notably slower than in many other plant storage organs. Work by Booth (1976) demonstrated that periderm formation occurred around small 'V' shaped cuts in the roots within four to seven days at 35°C. It would thus appear that the size of the wound sustained by the roots could affect the time required for a periderm to form.

In roots held at low storage humidity (45-55% RH), increases in phenol production did not remain localized below wound surfaces but spread down the roots preceding the development of vascular and storage parenchyma discoloration.

Spectrophotometric analysis of cassava root extracts demonstrated that considerable increases in total phenol, leucoanthocyanidin, and flavanol contents were occurring in these root pieces following injury. Increases in phenylalanine ammonia lyase activity, together with the increases in phenol content, indicate that the latter changes are at least partly due to the novo synthesis and not only to qualitative changes in the phenolic constituents.

The development of colored material in the storage parenchyma and vascular tissue was observed to be accompanied by localized increases in the activity of polyphenol oxidase and peroxidase. It was concluded from these results that some of the lignin-like cytochemical responses observed in the colored material were due to condensed tannins derived from leucoanthocyanidins and catechins.

The experiments show the complexity of the changes occurring in cassava roots in response to injury and substantiate previous indications that rapid postharvest deterioration of cassava roots normally commences as a nonspecific response to wounding.

TDRI/CIAT collaboration to reduce postharvest deterioration of cassava*

In some of the poorer and drier regions of the world, cassava is an excellent reserve against famine and one of the most economic sources of calories. This crop plays an important role in low-income sectors of developing countries; about 700 million people receive from 200 to 1000 calories per day from cassava.

In view of the importance that cassava has for the tropics, research and development institutes have produced higher yielding varieties, and have developed adequate low-input technologies to improve production. However, farmers have been reluctant to increase their production beyond a certain level in regions where the market is exclusively for fresh cassava because they either cannot sell it or low prices do not make it profitable.

The demand for fresh cassava, and therefore its production, could be increased if the differential between farm gate and consumer prices were reduced; this difference is large since the high postharvest deterioration of roots forces middlemen to look for higher margins of profit to compensate for the risk they are taking when buying cassava. In the Valle del Cauca, Colombia, for example, the farmer gets paid around US$0.05/kg of cassava whereas the consumer pays US$0.40/kg.

In the more affluent export markets, a solution to postharvest deterioration consists in packing roots in wooden boxes filled with saw dust or paper. This method preserves cassava for two weeks or more. The roots can also be frozen, prolonging their shelf life. These techniques, however, are not economically feasible for local markets where the greatest nutritional potential of cassava lies.

In a joint research program, the Tropical Development and Research Institute (TDRI) and CIAT have been looking for low-cost technological alternatives that will help small farmers prolong cassava's shelf life. Christopher Wheatley, a visiting TDRI scientist at CIAT, provided the information summarized below.

Causes and control of deterioration

Two independent types of deterioration, physiological and microbiological, account for fast deterioration of cassava.

The first to appear is physiological deterioration, in which starchy root tissues turn a blue-black color, especially near the xylem. Roots like this are not good for human consumption because they remain hard and taste bitter after being cooked. Although these symptoms only appear 24-48 hours after harvesting, they can be detected because they fluoresce bright blue when observed under ultraviolet light. If this fluorescence, produced by a particular phenol, scopoletin, is seen, it is a sure indication that deterioration is in progress. The blue pigments in deteriorated cassava are formed by the polymerization of phenolic compounds that accumulate after harvest.

Physiological deterioration begins in the wounded areas of the root, especially at the two ends, and it is an oxidation reaction that can be prevented by reducing the loss of humidity and the contact of damaged root area with air. This can be done by storing the roots under high relative humidities and temperatures (85% RH, 30-40° C). Cassava roots, like other crops, undergo "curing" under these conditions; however, such conditions favor the second type of deterioration, the microbial one.

Microbial deterioration consists of rotting induced by several pathogens that develop some five to seven days after harvest. The best control method is to treat the roots with thiabendazole fungicide. This treatment has given excellent protection against pathogens found in the Cauca Valley and on the Northern Coast of Colombia. Roots treated with this substance are edible since this method is currently used without problems with potatoes and bananas. In terms of toxic residues, cassava is safer than potatoes because its peel is much thicker and is completely removed before cooking.

To control both types of deterioration, CIAT has developed a technique in which roots are treated with thiabendazole** and packed in polyethylene bags. The fungicide prevents microbial growth and the bags provide the temperatures and relative humidities needed for "curing" to take place.

Treating and packing the roots must be done on the farm, since a delay of only four hours after harvest can increase losses after one week of storage from 2% to over 30%. From 1 to 20 kg of roots can be stored in each bag depending on the consumer or market preferences.

The procedure, as illustrated in the photo insert, allows cassava to be stored up to four weeks. However, starches are converted into sugars after two weeks, giving cooked roots an undesirable sweet flavor. Thus two weeks is the recommended maximum storage time. ▷

* Taken from CIAT International, vol. 3, no. 1, June 1984.

** CIAT has used Mertect 450 FW from CIBA-GEIGY at 0.4%.

Perspectives of postharvest preservation

Over the last 12 years in Cali, Colombia, urban consumption of cassava has fallen by 50%, prices have risen to over 200%, and the farmer is still getting paid a very low price.

This situation is primarily due to marketing problems which the new storage technology can help to mitigate. Reducing the risks of handling cassava would make cassava more appealing to middlemen, and their margin of profits could be reduced. Also, the advantage of well-preserved and low-cost roots would stimulate the demand and enable farmers to get a better price for their produce.

Improved storage technology could reduce the marketing margin in Valle to US$0.15-0.20/kg of roots from the current margin of US$0.35. The treatment is relatively inexpensive (US$0.02/kg of roots), which currently equals 5% of the cassava price in Cali.

It is necessary to convince the consumers, middlemen, and the farmers to adopt this method. Farmers of the Rozo region (near Cali) where farm trials were carried out liked the storage method and are looking for ways of adopting it on a commercial scale. Trials on the Northern Coast of Colombia and the Llanos Orientales have also given excellent results in spite of the prevailing warm climate.

Palatability tests are being carried out at the consumer and marketing levels with fresh and stored samples comparing cassava varieties. So far, the results show that roots stored up to two weeks have a similar acceptance to the fresh ones.

Finally, better knowledge of the urban marketing structure of fresh cassava is a very important step toward the integration of farmers, middlemen, and consumers in a chain allowing everyone to benefit from this new technology.

Steps in the treatment and storage of cassava in polyethylene bags

1

2

3

4

1. Select roots, discarding those that present considerable damage; generally 85-90% of the roots can be stored if harvesting is done carefully.
2. Pack 30-40 kg of roots in a sisal bag, then immerse each bag for five minutes in a 0.04% thiabendazole fungicide solution. This solution can be used 15 to 20 times.
3. Spread the roots out to dry in the shade for approximately 30 minutes before packing them in polyethylene bags. Bags should be sealed shut with tape, staples, or any other method.
4. **Store indoors at room temperature or outdoors in a place protected from rain and direct sun.**

The use of bitter cassava in Northwestern Amazon

Darna L. Dufour

Native Amazonians have traditionally cultivated both bitter and sweet cassava varieties. Sweet varieties have enjoyed a wider geographical distribution, but in certain areas, such as the Northwest Amazon, there has been and continues to be a strong cultural preference for the more bitter varieties.

Research carried out at Yapú in the Colombian Vaupés indicates that the Tukanoan Indians of the Tatuyo group cultivate over 30 cassava varieties, of which the bitter far outnumber the sweet. Bitter cassava is the dietary staple, providing about 80% of the total food energy. The remainder of the energy in the diet is obtained from other crops including sweet cassava, and from wild plants and animal foods, game, fish, and several insects, which provide 6% of the protein consumed.

Figure 1. *To eliminate HCN from bitter cassava the Tukanoan indians perform a tedious task every day. The photos for this article were taken at CIAT where Hortensia Gómez, a Tukanoan, was present.*

Processing of bitter cassava and cassava products among the Tukanoans

The Tukanoan technique for processing bitter cassava roots is elaborate and no doubt very old. The technique decreases the level of toxicity due to hydrocyanic acid and improves its storage characteristics, as well as providing the raw materials for a variety of foods (Figure 1).

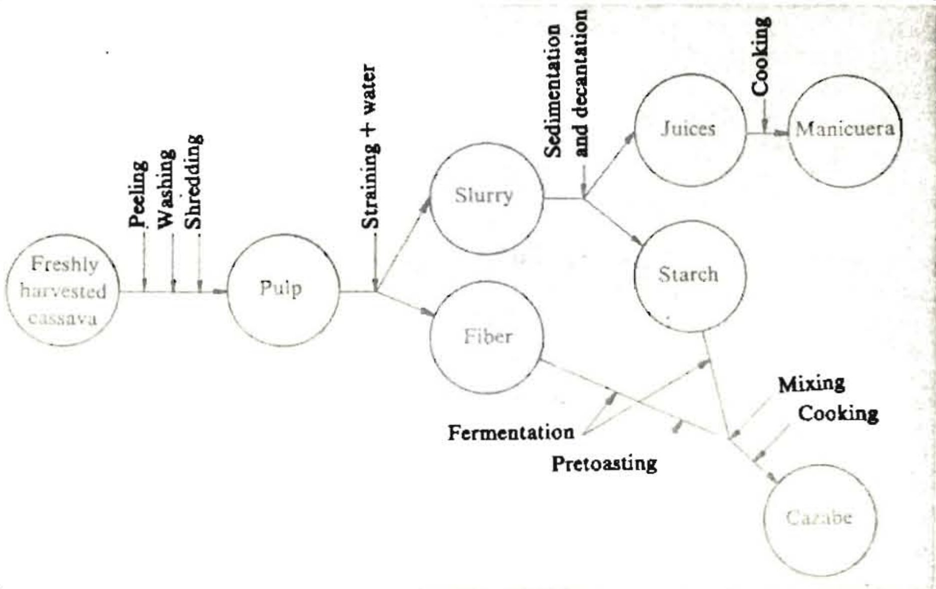

Figure 2. *Process used by the Tukanoan indians in Yapú, Vaupés (Colombia) for preparing bitter cassava and cazabe.*

Processing separates the roots into its components: liquids, starch, and fiber. This is accomplished by grating and straining. The process involves several steps (Figure 2). The freshly harvested roots are first peeled by scraping to remove the outermost layer of bark-like peel, but leaving much of the inner layer intact. After they are washed, they are grated on a wooden grating board set with small sharp quartz stones (Figure 3).

Figure 3. *Shredding of the root is a basic step in the bitter cassava processing; women do it daily.*

The resulting wet pulp is placed in a large basket strainer set on a tripod,

Figure 4. *Straining of the pulp on a strong sieve that men weave from palm.*

Figure 5. *After one or several days of fermentation, the fiber is squeezed in a matafrío o tipití; it is then milled, toasted, and mixed with starch to make the cazabe.*

Figure 6. *On a clay griddle (at CIAT a metallic one was used) the indians shape and bake the cazabe.*

rinsed with water, squeezed, kneaded, and pressed against the strainer to squeeze out the liquids (Figure 4).

The extracted liquids, which carry the starch in suspension, are collected under the strainer in a large clay pot. The starch is allowed to settle and the liquids are later decanted off the top to make juice.

Once separated, the starch and fiber are relatively stable and can be left in pots or leaf-lined baskets for several days or more. Under these storage conditions they ferment slightly, and it is in this form, rather than fresh, that they are used. Surpluses of starch and fiber which need to be stored for longer periods are usually buried in leaf-lined pits with the fiber covering the starch to prevent surface deterioration. The author observed products stored this way for more than a month.

The raw cassava juice is also used as food though it is a very unstable product and very toxic. Immediately after decantation it has to be boiled to evaporate the hydrocianic acid.

Cassava-based staples

The most important foods of the Tukanoan are made from cassava starch, fiber, and juice. They are: bread (cazabe), boiled juice (manicuera), and different starch-thickened drinks (mingao).

Cazabe. Most of the fermented starch and fiber produced in processing are used to prepare cassava bread. Cazabe can be prepared in a number of ways, but in the Vaupés one form is characteristic: a thick soft bread made by recombining the fermented fiber and starch for 2 or 3 days. To make this type of bread the fiber is first squeezed in a **matafrío** or **tipití** to reduce its moisture content (Figure 5) and then lightly toasted. This pretoasted fiber is mixed with moist starch and baked on a clay griddle in the form of a large round bread (Figure 6).

Cazabe is made daily. Although it can be stored, it is not customary to do so.

Manicuera. Boiled cassava juice is a slightly sweet drink known as manicuera that is served late in the afternoon or early evening; when it is not consumed it is discarded the next day.

Mingao. This is another drink, which is usually served at meals when manicuera is not available. Mingao is prepared by dissolving some of the fermented starch in boiling water and cooking it until thickened. It is a bland tasting beverage which is often flavored with palm fruits, pineapple, bananas, or lemon.

Fariña. When a carbohydrate source with good storage characteristics is needed, fariña is used. Fariña, a dry cassava meal (about 10% moisture), is a light weight, concentrated source of calories which can be stored almost indefinitely.

It is prepared when needed from yellow varieties of bitter cassava which have been soaked in water for two or three days, then peeled and grated. The resulting mash is mixed with grated fresh roots, allowed to ferment for at least several days, and preferably several weeks, and then toasted.

(Continues on p. 12)

Natural drying of cassava

A project with potential for the small producer

Ana Lucía de Román

A productive idea from the Canadian International Development Agency (CIDA), together with a modest economic contribution, gave support in 1981 to the joint activities of farmers, the DRI, and CIAT aimed at solving the problem of cassava marketing on the Atlantic Coast of Colombia.

The social and economic impact of this cassava drying project has reached other Latin American countries that are now trying to adapt and apply this methodology to their own needs. This shows the importance of relatively modest economic aid to countries that need it and the feasibility of a well-oriented relationship between the community and the institutional resources.

How long will the dried cassava boom last? This is a common question about the future of dried cassava as a solution to the marketing problems of cassava roots, and as an incentive to increase cassava cultivation in nonproductive tropical areas.

At least in Colombia, current trends point to a very optimistic answer. Cassava is a practical and profitable substitute for sorghum and other ingredients used in concentrates that are not produced locally in large quantities, and which are more and more difficult to obtain due to lack of currency and import restrictions.

The future of the natural drying project depends, however, on the official policies taken in relation to sorghum subsidies. If sorghum is subsidized, then dried cassava will not be able to compete with it and the efforts low-income producers have put into dried cassava thus far may have been in vain.

From the nutritional point of view, dried cassava is essentially an energy food, and its price as such is equivalent to 80-90% of that of sorghum. The enterprise buying cassava for its concentrates uses cassava roots in its mixtures at levels of 5 to 7%, depending on the type of feed manufactured.

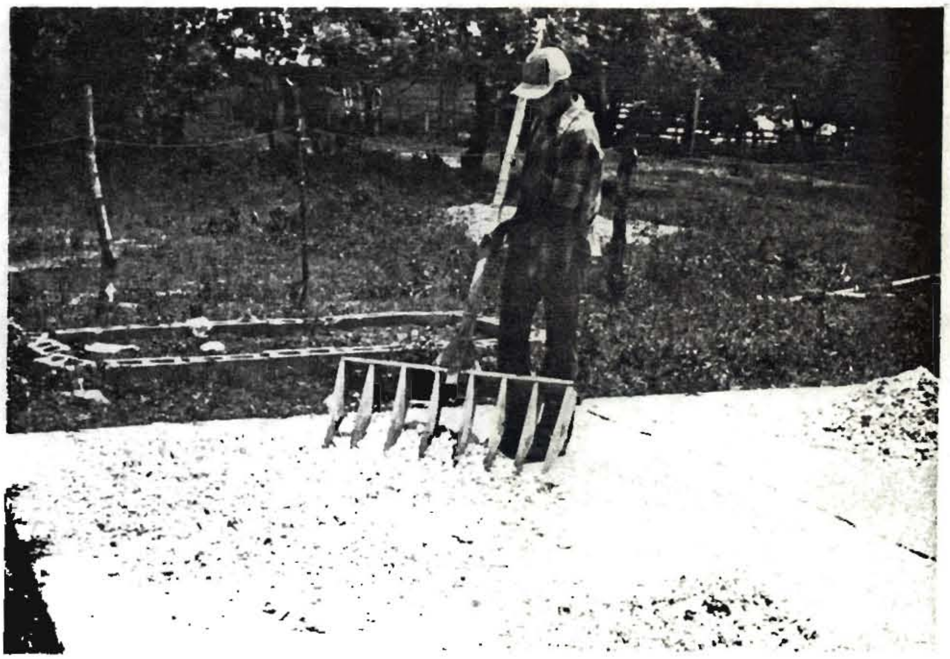

Figure 1. *Natural drying of cassava is a project that requires special consideration in national development policies.*

Experiences and evolution of the project

Since the project was launched in 1981 after the CIDA/CIAT-DRI* agreement (see Cassava Newsletter vol. 7, no.1, June 1983), the situation on the Northern Coast of Colombia has changed substantially. From 17 farmers that originally decided to try the new technology to solve their problems of cassava marketing, the number has risen to 140 (June/84), affiliated to seven associations. Their drying plants have drying patios 7200 m² in area, and five of them have their own warehouse. Even nonassociated growers find these plants to be the best alternative to fresh cassava marketing.

* CIDA = Canadian International Development Agency; DRI = Integrated Rural Development Program of the Colombian government.

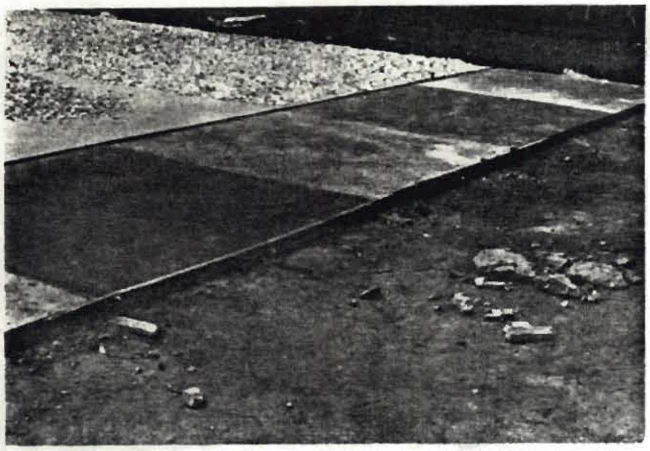

Figure 2. *In 1984 the associations are increasing their drying capacity by 125%, allowing them to produce 2000 t of dried cassava per year. Using iron reinforcing bars and expansion spaces between concrete slabs, as recommended by CIAT, farmers make their own enlargements.*

Figure 3. *Regional testing of materials and agronomic research in general are basic to the present and future of the project.*

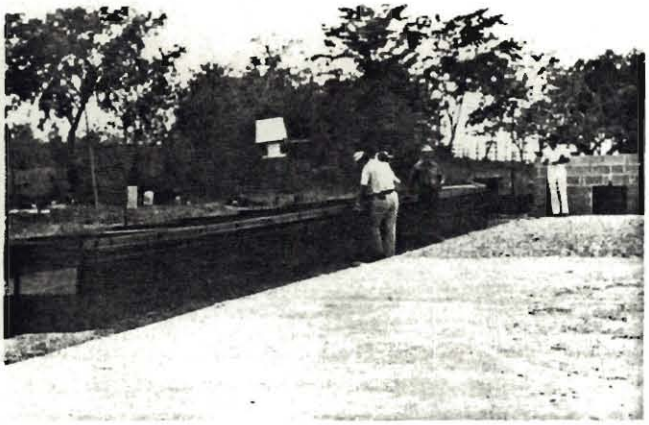

Figure 4. *Next to the natural drying patio at Montañitas, an artificial drying device has been installed, consisting of a fixed bed system with forced air and a solar energy collector as the source of heat.*

Making sure that the moisture content of the product is reduced to no more than 14% in the drying process is the most crucial and perhaps most difficult aspect of the project. In new plants, special attention should be given to this aspect. However, with sufficient practice it is no longer a problem.

Excess moisture in the final product may cause the purchaser to refuse it, and sending it back for redrying would be economically prohibitive. For example, in Betulia where there are three associations, transportation costs of dried cassava to Cartagena are US $13/t (4-hour journey); drying costs are $3.10-3.50/t and require 2.5-3.0 days of work/t (August/84).

Good operation of the equipment (chipper and motor) is another important factor. Experience has shown the need to train one person in every plant to operate and repair equipment in order to avoid delays caused by frequent break-downs.

The idea of a federation of associations of producers, proposed initially by the institutions related to the project, has been widely accepted by the farmers. As one farmer said, "We think that this organization should expand, that all the farmers of the Atlantic Coast should belong to it, and that it should spread to other countries".

The first step taken toward the creation of such a federation was the meeting between the managers of the seven plants and representatives of Purina to negotiate the next harvest (1000 t of dried cassava). Volumes and dates of deliveries, payments, and other business aspects were discussed. Though no further advances have been made, the establishment of this Federation (FEDEPROYUSCA = Federación de Productores de Yuca Seca de la Costa Atlántica) is still a priority.

Supportive activities of the project

In order to have dried cassava all year long, artificial drying during the rainy season is being tested and agronomic research has been undertaken to produce cassava at different times of the year.

The artificial drying experiments are carried out at the APROBE (Asociación de Productores de Betulia) plant. The experiments use a solar energy collector connected to a fixed bed deposit. For less sunny periods a carbon heater, easily obtained in the region, can be used.

Key to success

"The problem is not solved yet but we are on the way" the APROBE manager said with enthusiasm, referring to the success obtained so far. Bernardo Ospina, the agricultural engineer in charge of establishing and advising the plants, affirms, "The future of the project is ensured; a problem might be in how fast the farmers obtain three nontechnical elements that are crucial: organization, education, and discipline; this is where most of the institutional efforts must be directed".

Organization and discipline are needed for meeting group objectives and for efficient and well-timed processing. Responsibilities of the members in the different committees and activities are very important, especially for the plant managers who must act as leaders within the groups.

Training is a general need felt not only by the entities involved in the project but by the farmers as well. In relation to this, SENA (Servicio Nacional de Aprendizaje), a training institution, is revising its methodology looking for ways to make the producers more active in the programs. Young leaders, with better educational background, are also trained through workshops and "long distance" training programs. The illiteracy index is very high, hence the need for adult literacy programs to expand participation in project activities and to prevent decision-marking from being in the hands of a few.

Figure 5. *To share their bad and good experiences is one of their duties that the associations leaders do with pleasure. In the picture Santamaria Erazo (back to the camera) and other neighbors with Latin American professionals.*

Figure 6. *Young, well-prepared members of the community are very helpful to the associations. One of them, José Ortega, is in charge of the operation and maintenance of the chipper and motor in APROBE.*

Finally, the cooperation between all the institutions related to the project has been one of the most important bases for the development of its activities. Roberto Pérez, DRI-PAN Director (Integrated Rural Development-Food and Nutrition Program) in the Department of Sucre, says, "The project itself does not satisfy me as much as the fact that we have learned to work as a team, with the benefit of the farmer as our ultimate goal". Inter-institutional cooperation has taken place at the three stages of the project: production, processing, and commercialization.

The social function

"The first time I visited Betulia, 'el Chacho' was there with his group, talking with resentment and complaining about politics, good-for-nothing institutions, everything. He still talks the same way, but with a different attitude, now he sees a future for himself, his family, for everyone". With this comment, Dr. James H. Cock, Coordinator of CIAT's Cassava Program, highlights one of the main achievements of the project, its social impact.

The feasibility that big agricultural entrepeneurs get involved in dried cassava production is small, although it does exists. However, according to Felipe Consuegra, quality control manager of Purina, the industry prefers the small farmer associations rather than the big groups because the former are more stable. The big ones shift from crop to crop when they see better comparative advantages. Therefore as a business and as a social function, "the presence of the large groups cannot be permitted to displace the small associated farmers".

It is important to mention that two new purchasing enterprises have entered the market of dried cassava this year which bought 10% of the production, and that there are other processing plants whose potential demands cannot be satisfied at the moment. In any case, the trends in the concentrate industry and the positive attitude of Purina toward dried cassava "as long as the prices are competitive" are stimulating, not only for Colombia but for other countries with similar ecological and socioeconomic conditions.

Panama toward the production of dried cassava

This year Panama launched the experimental phase of a project for natural cassava drying. The Instituto de Investigación Agropecuaria de Panamá (IDIAP) is responsible for the project's activities and CIAT is providing technical assistance. The plant is located in the settlement "Unión Campesina", in the Llanos de Ocú (Herrera province), and the facilities include a 500 m^2 concrete patio, a small 16 m^2 house for the chipper and its motor, and other implements.

Traditionally Ocú district has been a yam and cassava producing region; cassava cultivation was highly stimulated in the 70's with the creation of an agrobusiness in the area. This, however, did not thrive and since then farmers have been subjected to the ups and downs of the supply and demand. This year prices have fallen drastically and production has increased because of suspension of credits to rice growers by the Ministry of Agriculture and Livestock Development.

Advances of the Panamanian project

Until late March, 1984, the plant had dried 30.3 tons of fresh cassava from a 7-ha lot cultivated under the project; on the average, the ratio of fresh cassava-dried cassava was 2.4:1, and 54.2 hours of drying were required per lot. These figures are similar to those obtained in Colombia.

With the experience gained the plant could process in the future three lots of cassava weekly, with a 10-12 kg load/m^2 and a man day's of work per ton of fresh cassava.

Table 1 summarizes the costs of facilities, equipment, and maintenance; processing costs are presented in Table 2. Production costs of raw materials are not included due to inconsistent infor-

Figure 1. *To obtain information on the cassava drying project and its possibilities in Panama, 120 farmers and technicians attended the field day held by IDIAP in April in the settlement "Unión Campesina".*

Table 1. **Costs, depreciation, and maintenance of the cassava drying plant located in the settlement "Unión Campesina", Llanos de Ocú, February, 1984.**

Item	Useful life (years)	Value (US$)	Annual depreciation Proportion[1] (%)	Annual depreciation Value (US$)	Annual maintenance Proportion[1] (%)	Annual maintenance Value (US$)
A. Facilities						
Concrete patio and chopping area	20	3850	5	192.50	2	77
Fence, wire mesh, barbed wire, pillars and clamps	5	400	20	80	5	20
B. Equipment						
Chipper	10	1000	10	100	5	50
Gasoline motor (5 HP and accesories)	5	400	20	80	15	60
Scale	20	810	5	45	3	24
C. Tools						
Shovels, rakes, collectors	2	140	50	70		
Wheelbarrow	5	90	20	18		
Plastic tent	4	356	25	89		
Bags	2	100	50	50		
D. Contingencies (5%)		357	20	71		
Total		7503		791.50		231

[1] Percentage value of each item.

mation. Payment received by farmers varies and sometimes fresh cassava has no set price in Ocú due to excess supply on the market.

Who is going to buy dried cassava?

The future use of the dried cassava produced by IDIAP will be for its own research on the use of this product in pig and poultry rations. Results will be published and the use of the product by industry will be monitored. An experienced professional has been hired by IDIAP to conduct feeding trials with pigs at the Faculty of Agronomy in David, Chiriquí, and in Divisa with the Instituto Nacional Agrícola (INA).

Table 2. **Costs of processing one ton of dried cassava during the experimental phase of the drying plant at "Unión Campesina" in Panama.**

Item	Value[1] (US$)	Observations
Management	4.3	One manager for four months; 115 t of dried cassava per season.
Equipment maintenance	2	Same as Table 1
Equipment depreciation	6.9	Same as Table 1
Labor	10	Adjusted, 1 day's work/t of fresh cassava
Fuel	2.5	
Contingencies	2.5	10% of other costs
Total	28.2	

1. Cost in March, 1984.

There is a possibility to promote sales of dried cassava to the nearby industries in Ocú or Panama. "Toledano" made the best price offer among concentrate producers contacted: dried ground cassava delivered to Panama at US$187/t. IDIAP does not have experience with grinding, but estimates of this operation and transport costs to Panama indicate that this first offer could be the opportunity to initiate operations on a semicommercial scale.

Future plans

For the project to prosper, farmers from the settlement will have to grow enough cassava for the 1984-85 harvest to supply the pilot plant, and the industry should support the project. Generally, concentrate manufacturers have been reluctant to commit themselves to buy exact amounts of dried cassava, probably due to the fact that cassava and corn harvesting times coincide, and that corn prices are the lowest at that time.

IDIAP, a research entity, cannot assume overall responsibility for the project during its next phases. It can continue with agronomic research and studies on the use of cassava in animal nutrition and bakery products; however, the participation of other institutions, through extension, financing, agricultural engineering, education, and other complementary areas, is required. □

The use of bitter cassava ... (Continued from page 7)

General observations

The processing and cooking techniques developed by Tukanoans are used to produce a variety of foods from bitter cassava. The efficacy of the processing techniques used in reducing the level of toxicity in bitter cassava is not known with any degree of certainity, but preliminary studies carried out suggest that they are very efficient.

The nutritional status of Tukanoans is generally good (Table 1) and there do not appear to be any problems, nutritional or otherwise, associated with their high reliance on bitter cassava.

Table 1. **Sources of food energy consumed in four Tukanoan households, according to a survey carried out in November 1978[1].**

Source[2]	Percentage of total energy per household				Mean
	I	II	III	IV	
Bitter cassava	86	72	92	83	83
Other crops[3]	2	8	3	7	5
Wild plants	1	1	1	1	1
Fish	4	18	3	5	8
Game	0	0	1	3	1
Insects	7	1	0	0	2
TOTAL	100	100	100	100	100

1. Household food consumption was determined using a modified larder method.
2. Data were collected at the beginning of the principal dry season when both wild plants and insects are of limited importante.
3. Includes sweet cassava which, like other root crops, is used principally in the preparation of cassava beer (chicha). □

Advances in storage and utilization of cassava in the Philippines*

In the Philippines cassava's potential as a feedstuff and as a source of energy has not only caught the attention of the government but of the private enterprises as well. Policymakers and research programs have given cassava production special priority.

In view of the present economic crisis, the government has taken steps to cancel or reduce the importation of several products and to develop substitutes for them. The possibility of substituting cassava for some of the 600,000 tons of corn imported per year has made government and private sectors enthusiastic about cassava cultivation. Feed mill operators are also optimistic. However, given the high postharvest deterioration of the roots, farmers will only increase their cassava production if they are able to increase its shelf life.

A pilot feed mill for root crops

Recently the Visayas State College of Agriculture (ViSCA) launched its pilot feed mill using root crops instead of corn. The project, whose ultimate goal is to increase farmers' income by creating a stable market for their produce, has three specific objectives:

a) To demonstrate to the farmers the feasibility of formulating quality feeds using locally available ingredients such as root crops and other raw materials.
b) To provide a ready market for the feed ingredients produced by farmers and fishermen (for fish meal).
c) To provide a steady supply of low-cost quality animal feeds to animal raisers in Leyte and neighboring provinces.

Activities for the first phase of the project include studying the feasibility of substituting corn for root crops in feed formulations, organizing and training root crop growers from nearby villages, and negotiating with suppliers of other feed ingredients, such as fishermen for fish meal. Livestock scientists are responsible for quality control of the feeds and feed ingredients, and the ViSCA feed mill sets the price for dried cassava chips.

In the expansion phase more farmers will be organized and other feed mills established. The Ministry of Agriculture, particularly its Bureaus of Animal Industry and Agricultural Extension, will be responsible for the continuity of the activities after the project is over. Root crop producers should have, at that time, a strong linkage with feed mill operators.

Agricultural engineers of the Philippine Root Crop Research and Training Center (PRCRTC) have designed and developed village-level processing machines. One of them is a pedal-operated chipper-grater that costs around US$83.50 and can process, under normal conditions, an average of 285 kg of roots per hour.

Other technologies under study

The PRCRTC has also developed a practical village-level storage technique for cassava; observations show that cassava root quality is not affected for a period of up to three months when roots are buried immediately after harvesting. Related research indicated that pruning cassava plants two to three weeks before harvest significantly reduced vascular discoloration and delayed the incidence of decay for a week.

The pre-processing of cassava into dehydrated cubes for storage before its use as an ingredient in some snack items has also been studied at the PRCRTC. A technique for the manufacture of soy sauce from cassava and sweet potato flours also has been developed. This product is called "Root Soy Sauce," and after having been accepted by consumers, it is being evaluated at a marketing level. Other cassava-based products are being developed and the processing techniques are undergoing improvements.

Studies on the use of cassava as an energy source for poultry showed that 85% cassava meal plus 15% soybean meal in the feed ration approximates the feed value of corn; if pellet feeds are used, cassava can totally replace corn. For broiler rations up to 30% cassava can be used. More recent studies have shown that cassava can replace up to 80-100% of the corn in layer rations, and that utilizing yellow cassava in the poultry rations increases the yellow pigmentation of the yolk.

Research being conducted in pig feeds has revealed that cassava can completely replace corn in the diet of finishing pigs. Carcass quality of pigs fed with cassava is as good as that of corn-fed pigs. For younger pigs, a maximum replacement of 70% corn is recommended.

Feeds consumed in pellet form improve feed intake, weight gain, and feed conversion efficiency.

Future directions in cassava research

Emphasis will be given to the following objectives:

a) Maximize the use of cassava as a substitute of yellow corn in concentrates.
b) Promote the production and utilization of cassava flour for bakery products by using improved processing techniques and equipment, and by identifying cassava varieties with high starch contents.
c) Develop new cassava-based products and improve those already existing. □

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* Source: Paper presented by Algerico M. Mariscal of the Visayas State College of Agriculture (Philippines) at the workshop on the Future Potential of Cassava in Asia and Research Development Needs, held from June 5 to 8, 1984, in Bangkok, Thailand.

High yield combined with improved quality in cassava

J. S. Jos and N. Hrishi report the following from the Central Tuber Crops Research Institute at Trivandrum, India:

Two high-yielding hybrids, H-1687 (Figure 1) and H-2304, have dramatically and consistently out-produced local varieties and controls in trials conducted over the last few years. These hybrids also show marked improvement in nutritional and consumer acceptance characteristics. H-1687 is a cross between an indigenous and exotic variety, while H-2304 is a multiple cross involving five parents, of which two are exotic (one a high quality Malayan type and the other a Madagascar type with high field resistance to mosaic). Both hybrids maintained their superiority over the controls in all the trials in different years.

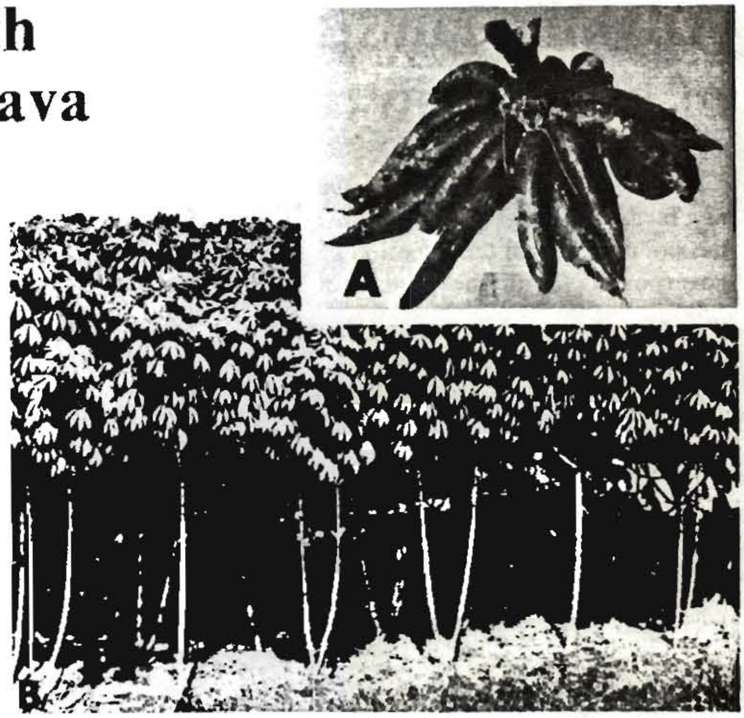

Figure 1. *H-1687. a) Plantation b) Roots.*

The yield from H-1687 varied from 30.2 to 43.3 t/ha under farm conditions. Similarly, in H-2304 the yield ranged from 34.9 to 41.8 t/ha. These yields were significantly superior to those of the local varieties, which ranged from 11.1 to 21.9 t/ha. When tested under different agro-climatic conditions, they out-yielded the controls in all locations. H-2304 showed a mean yield of 43.2 t/ha while H-1687 produced 38.7 t/ha. The improved local M-4 yielded only 28.5 t/ha. In minikit trials spread throughout Kerala state, these hybrids were further tested in 138 plots. H-2304 had a yield ranging from 30.41 to 58.39 t/ha and a mean of 44.99 t/ha. The mean recorded for H-1687 was 44.05 t/ha, compared to 30.43 t/ha for the local varieties.

The H-2304 hybrid has a significantly higher dry matter content and the starch content is about 29%. The tubers are non-bitter in both hybrids, and HCN content is zero after cooking. The hybrids were tested for acceptability among a cross section of population and the pooled data for the state showed that they had distinctly higher acceptance than the local varieties.

The carotene content of H-1687 is 466.1 IU/100 g and the flesh is yellow after cooking. Carotene, which is a precursor of vitamin A, makes this hybrid nutritionally more attractive. The production of a high-yielding variety that also contains carotene is a significant achievement in combining quality with quantity in cassava.

Aflatoxins in cassava . . . (Continued from page 2)

such as two-dimensional TLC*. Another simpler method consists in exposing the fluorescent extract to iodine vapor; iodine quenches the fluorescence of scopoletin without affecting that of aflatoxin (Nagarajan et al., 1973)**. Using this procedure, both dried cassava chips and fresh root samples suspected of containing aflatoxins B_1 have been shown to contain only the nontoxic scopoletin. This indicates the importance of satisfactory sample preparation to remove interfering compounds, or the use of confirmatory tests for aflatoxins before assuming that cassava samples contain high levels of aflatoxin.

On the other hand, fresh cassava is generally consumed immediately, and *A. flavus* needs at least 48 hours to develop and produce the toxin. Therefore, fresh cassava consumption implies less risk of aflatoxin intake than other root crops used as sources of carbohydrates (yam, potato, sweet potato) that are generally stored for longer periods of time.

While care should be taken to avoid consumption of moldy cassava or cassava products, the extreme susceptibility of cassava to aflatoxin contamination implied in some reports has been exagerated.

* Those interested in these reports can request their bibliographic citations from Dr. Christopher Wheatley, CIAT, Apartado 6713, Cali, Colombia.

** Nagarajan, V.; Ramesh V. Bhat; and P. G. Tulpule. Aflatoxin-like factor in tapioca. Environment Physiological Biochemistry. 3(1):13-18.

Cassava potential and research in Asia

Workshop sponsored by ESCAP CGPRT Center and CIAT, 5-8 June, 1984, Bangkok

Figure 1. *Work meeting at the U.N. building in Bangkok.*

Figure 2. *Visit to the Rayong Experimental Station.*

Figure 3. *Visit to a cassava starch plant east of Bangkok.*

For more than 50 participants attending the workshop in Bangkok, the three days of presentations and discussions represented a valuable opportunity to obtain updated information on cassava cultivation in eight Asian countries and to participate in economic and agronomic analyses of regional scope.

Participating countries were: China, India, Indonesia, Malaysia, Bangladesh, Sri Lanka, Philippines, and Thailand. Several international entities and representatives of private enterprises in Thailand were also present and actively participated; 50% of the registration corresponded to the latter groups.

The workshop fulfilled the expectations of ESCAP CGPRT Center (Economic and Social Commission for Asia and the Pacific, Coarse Grains, Pulses, Roots and Tuber Crops Centre) and CIAT, the two entities that sponsored the event with the collaboration of the Thai government and the Ford Foundation. The ESCAP CGPRT Center is an entity recently established in Bogor, Indonesia, to encourage the production of crops which come under their mandate (among them cassava), and to promote research on them in the region. CIAT has a global mandate for research on cassava (except Africa). Recently a CIAT plant breeder was stationed in Bangkok, Thailand, to work with the cassava-producing countries of the region on germplasm exchange and improvement.

The objectives of the sponsoring entities were to assess and discuss the potential increase in production, utilization, and marketing of cassava in Asia; to identify efficient technologies for these purposes; and to promote the creation of a collaborative regional research network.

Two papers from each country were presented:one related to the economics of production, consumption, and marketing; the other related to agronomy and research. Additional economic presentations dealt with the perspectives of cassava in the world economy, production and utilization trends and their comparative analysis in tropical Asia, and analysis of international marketing of cassava pellets and starch.

The research and agronomic topics were presented individually by six countries; in addition, the agronomic potential of cassava in upland areas of tropical Asia, current situation and prospects of improved cassava production, and CIAT germplasm for Asian cassava research programs were analyzed.

At the end of the meeting, the proceedings of which are being edited for publication by CIAT, the following general recommendations were given: the potential productivity of cassava should be increased through improved varieties, agronomic and socioeconomic research, extension and training; the limited research capabilities of the countries should be pooled together through a research network and through exchange of germplasm and information; postharvest and processing technologies should be improved, and new markets explored.

Susana Amaya

Literature review

Logros y aportaciones de la investigación agrícola en el cultivo de la yuca. (Achievements and contributions of agricultural research to cassava cultivation). Instituto Nacional de Investigaciones Agrícolas. Secretaría de Agricultura y Recursos Hidráulicos. 1983. México. Publicación especial no. 108.

The direction that the National Institute of Agricultural Research has given its activities is described, as well as the main results obtained in breeding programs for the hybridization of two varieties, Sabanera 1 and Costeña 1. Results of the identification of higher yielding accessions, research on cultural practices, harvesting, processing, and different ways of using cassava are also given.

Investigación agrícola adaptativa en pequeña escala ente los cultivadores de arroz y yuca de República Dominicana

Adaptive agricultural research on small-scale rice and cassava growers in Dominican Republic

Annual Report 1982. Agricultural Development Center (CENDA) and Rural Sociology Department for the Tropics and Sub-Tropics of the Agricultural University of Wageningen. Case studies in specific areas within the project of adaptive research jointly carried out by Wageningen Agricultural University and CENDA are given. The diagnosis will help in designing adaptive trials and field surveys among rice and cassava growers.

Preliminary results for the first year show that cassava growers in the Sierra region, who depend on hillside rainfed agriculture, were remarkably rapid in adapting their cropping system to changing ecological and market demands. The results also indicate that a cassava harvesting device, developed in Surinam, can markedly reduce physical strain of the growers who use it in particular cropping systems. Finally, it was observed that to produce a ton of cassava under hillside farming conditions in the Sierra region probably costs twice as much as existing calculations indicate.

The world market for starch and starch products with particular reference to cassava (tapioca) starch

S. F. Jones, TDRI (Tropical Development Research Institute). June 1983.

With this report TDRI intends to give current and potential producers in developing countries a global picture of markets and industries to serve as a reference in indepth analysis of export projects. Without going into detail, it presents data and discussions on the starch industry, worldwide production and trade, marketing chains and requirements, prospects of exportation, and related subjects, with emphasis on developing countries.

New publications

CTCRI News is a newsletter from the Center for Tuber Crops Research Institute of India. This newsletter will be published biannually and sent to researchers and individuals interested in tuber production in India. The first issue appeared in May 1984. **Cassava Newsletter** wishes CTCRI much success with this endeavor.

CIAT Bibliographies on Cassava*

1. Enfermedades virales de la yuca (Viral diseases of cassava). Summaries in English and Spanish, 14 pages and 195 references from 1924 to 1982.
2. Enfermedades bacterianas y fungosas de la yuca (Bacterial and fungal diseases of cassava). Summaries in English and Spanish, 100 pages and 448 references for the period 1922-1983.
3. Bibliography on vesicular arbuscular mycorrhyzae, 146 pages and 1235 references for 1922-1983.

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* Photocopies can be requested from CIAT's Communication and Information Support Unit. Payments can be made in US$ making out checks to CIAT, or in Colombian pesos adding the bank fee. CIAT, AGRINTER, or UNESCO coupons may also be used. Prices per page are US$0.10 or Col$4.00 in Colombia, and US$0.20 outside Colombia (including freight). Bibliography no. 3 has a special price of US$6.00 at CIAT, $7 if mailed within Colombia, $8 in the Americas, and $10 in other countries.

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