Processing of cassava tuber meals and chips
by B. Ospina and C. Wheatley

PART I: TECHNICAL ASPECTS OF CASSAVA PROCESSING.

INTRODUCTION

Over the past 25 years significant market opportunities for cassava have opened up in the animal feed industry, initially in the EEC countries but more recently for the rapidly expanding animal feed industries of tropical developing countries. Cassava roots compete with other carbohydrate sources, especially maize and sorghum, on the basis of price, nutritional value, quality and availability.

Cassava has several advantages compared with other carbohydrate sources, especially other root crops. It has a high productivity under marginal climatic and soil fertility conditions, which result in a low cost raw material. Root dry matter content is higher than other root crops, at 35–40%, giving optimum conversion rates of 2.5:1 or better. Over 85% of root dry matter consists of highly digestible starch. Cassava starch has excellent agglutinant properties which make it especially suitable for shrimp and fish feed, replacing expensive artificial agglutinants.

The potential disadvantages of cassava roots are their bulk and rapid perishability, their low protein content and the presence of cyanide in all root tissues. Through simple processing, the disadvantages of bulk and perishability can be overcome: a stable product is reached when moisture content falls below 14%. Natural drying is widely used to achieve this objective. Drying also permits the elimination of most of the cyanide from root tissues. The dried cassava product thus has only one disadvantage with respect to other carbohydrate feed sources: low protein content. This can be overcome through price competitiveness.

For export markets, where transportation over thousands of kilometres is necessary, further processing to produce high density pellets is carried out to minimize transport costs.

PROCESS DESCRIPTION

All countries where dried cassava is produced for sale to animal feed industries use essentially similar processing technologies. Cassava roots are transported to the processing plant, where they are chipped and sundried for two-three days before being packed and stored prior to further processing or transportation to industrial clients. This process will be described in more detail, and various processing variables which affect product quality or process economics will be mentioned. Detailed, technical information on the different processes can be found in Best 1978; Thanh and Lohani 1978 and Best and Gómez, 1985.

Harvest and transport of fresh roots

Roots are usually harvested manually, and transported the same day to processing plants.
The distance from field to processing plant must be short: cassava contains 65% water and transport is not economic. The need to minimize fresh root transportation costs favours the use of many, small to medium sized processing units rather than a few large scale operations.

Rapid fresh root perishability, due to physiological deterioration which initiates 1–3 days after harvest, necessitates rapid processing of the fresh roots. Although storage times of 2–4 weeks can be achieved using a variety of methods, none are cost-effective for the purpose of permitting the holding of stocks at the processing plant.

Processing plants must be ensured of almost daily deliveries of raw material, and can only operate during cassava harvesting periods. A positive correlation exists between physiological deterioration and root dry matter content i.e. those roots which are of best quality for processing are precisely those which deteriorate fastest. Excellent links between producers and processors are necessary to ensure that freshly harvested cassava is delivered to the plant as and when required. If fresh roots are held at the plant for over 5 days before processing is initiated, the possibility of end-product contamination with aflatoxin is much increased.

**Chipping**

Size reduction of cassava roots shortens the drying time and ensures efficient elimination of the cyanide component present in the fresh root. Roots may be chipped manually, using a knife (Indonesia, Colombia) in which case a few, large root pieces may take many days to dry and produce a poor quality product. In Thailand and most of Latin America, cassava chippers based on an original Thai design are used, powered by a 7Hp motor. Roots are chipped by a rotating disc either perforated with holes with cutting edges, or provided with interchangeable corrugated blades. In Brazil, a machine to produce rectangular chips has been designed.

Table 1 gives the dimensions of the typical chips produced by these machines. However, in practice less than 50% of chips actually fall within these measurements: a large percentage are broken or below size. Chip size and geometry affects the drying rate, especially when drying is conducted on inclined trays (Fig. 1). On concrete floors, Castillo and Hernández (1986) found minimal differences between these three types of machine. In Colombia, the efficiency of the basic model Thai chipper has been improved, principally through the design of more effective cutting blades. Capacity has been increased from 3 to 12 ton/hr. Several countries have developed manual or pedal powered chippers, eg. India, Indonesia, Peru and Colombia, but in practice they have been little used date.

**TABLE 1. Differences in chip geometry: dimensions of typical chips.**

<table>
<thead>
<tr>
<th>Shipping machine</th>
<th>Dimensions (mm)</th>
<th>% chips with these dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length</td>
<td>Width</td>
</tr>
<tr>
<td>Thailand</td>
<td>60–80</td>
<td>25–30</td>
</tr>
<tr>
<td>Brazil</td>
<td>50–70</td>
<td>10</td>
</tr>
<tr>
<td>Malaysia</td>
<td>50–80</td>
<td>4–5</td>
</tr>
</tbody>
</table>

Fig.1: Effect of chip geometry on drying time (loading rate 10kg/m²)
Natural drying

All cassava roots processed for animal feed are dried using natural solar radiation. Drying time depends on climatic conditions and chip size and loading rate amongst other variables. In most situations, drying is carried out on concrete floors. Drying on inclined trays is a faster option (Fig. 2) but with greater initial investment and a shorter working life. Under normal conditions at CIAT and in the Atlantic Coast region of Colombia, chips produced by the Thai type chipper at a 10 kg/m$^2$ loading rate dry in two days to below 14% moisture. Drying times in excess of three days can result in quality problems. Natural drying is normally confined to dry season months. However, recent experiences in Colombia suggest that processing plants can continue to operate economically and produce a good quality product even during months with significant rainfall providing that loading rates are reduced and more care is taken in plant operation.

Fig.2: Comparison of floor vs.tray drying of cassava chips (adapted from: Best, 1979)
The two day period taken to reach a 14% final moisture content also allows substantial reduction in total cyanide content. Fig. 3 shows that fresh chips of MCol 1684 and CM 342-170 were highly toxic at over 1000 ppm on a dry weight basis (OVER 300 ppm, fresh weight), but fell to below 50 ppm after drying. Oven drying at 60°C, with a 8 hour time taken to reach below 14% moisture content, resulted in dried chips with unacceptably high cyanide.
levels, Gómez and Valdivieso (1984). Natural drying thus represents the best option for reducing potential problems with cyanide toxicity. Neither European cassava importers, nor Colombian animal feed companies using cassava, have ever expressed concern over HCN levels in the naturally dried product as commercially available.

Natural drying requires considerable drying floor areas, even for moderately sized operations. In Colombia, floor areas range from 250 m$^2$ to 3000 m$^2$, with one 5000 m$^2$ plant under construction. In Thailand, plants with 35,000 m$^2$ of drying floor, and totally mechanized operation, are common. During drying, the chips need to be turned every two hours. This can be carried out manually, using rakes, or mechanically using equipment attached to tractors. Collection of the dried product can be similarly arranged. In Latin America, the dried cassava is usually packed into 50 kg sacks when dry, and stored in warehouses at the plant. In Thailand, the loose chips are transported directly to the pellet factories. The drying operation has minimal waste: roots are chipped unpeeled, and are stored as such once dry.

**Further processing**

Three options exist:

a. dried chips to the animal feed industry, which mills them and carries out the subsequent mixing and formulation (eg. Colombia, Brazil).

b. Milling of dried chips, and sale of cassava flour to animal feed or other industries (eg. Ecuador).

c. Sale of chips to pellet factory, for processing into an export commodity (Thailand).

A further potential option exists, as yet unrealized: formulation and production of animal feed rations by the processing plant itself. A trial of milling cassava flour, mixing with other locally available animal feed components and the use of this feed by local livestock farmers has been successfully completed in Colombia.

**PROCESS ECONOMICS**

The production of dried cassava for export is an important industry in Thailand and Indonesia. Dried cassava is currently produced for local animal feed industries in Colombia, Ecuador, Brazil, Panama and Bolivia. In other countries, some use of dried cassava undoubtedly exists, but at a less commercial level. The economics of cassava vs. other sources of carbohydrate will not be considered here: only the relative importance of different costs in determining the final price of cassava chips.

In the case of Colombia (Table 2) (Ostertag, 1990), the majority of the costs (74%) are represented by the price of the raw material (the fresh roots) including the cost of transport to the plant. The conversion rate of fresh to dried cassava is thus of crucial importance to the profitability of the enterprise. The use of high dry matter content varieties is recommended.

Processing costs comprise only 17% of total costs. These are due mainly to the labour costs involved in process operations. With total costs of Col.$69,000 compared with a selling price of Col.$91,000, there is ample margin available for the enterprise, and for covering financial costs involved in the initial capital investment. These have not been included in the analysis since conditions and amount of credit vary greatly between individual plants.

**TABLE 2. Processing costs, dried cassava, Colombia 1990**

<table>
<thead>
<tr>
<th></th>
<th>Col.$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw material</td>
<td>514000</td>
<td>74</td>
</tr>
<tr>
<td>Labour</td>
<td>69000</td>
<td>10</td>
</tr>
</tbody>
</table>
ORGANIZATIONAL ASPECTS

In Asia, individual or family run enterprises are the usual organizational form found for initial cassava processing. In Indonesia, village cooperatives perform wholesale, milling and pelleting activities. In Latin America, cooperatives and associations of small farmers dominate the production of dried cassava, although the private sector is growing in importance (40% of production in Colombia in 1990).

For cooperatives of small farmers to function adequately in the operations of processing cassava, and to manage the business aspects of the enterprise, substantial investment in technical assistance is required. In Colombia, Ecuador and Brazil, inter-institutional teams coordinated by rural development or extension agencies have been crucial to the growing success of the dried cassava cooperatives during the 1980's. The 1990's will see second order cassava producer/processor organizations take over some of these support functions.

NEW TECHNOLOGIES

More sophisticated drying technologies have potential for use to produce dried cassava for animal feed. Artificial or mixed drying systems result in a better quality product for all characteristics except cyanide content. Several artificial drying systems, described in Best and Gómez 1985, have been developed. However, the economic feasibility of such systems is uncertain. For animal feed, cassava must be cost competitive with maize and sorghum. Increases in processing costs due to artificial drying will not be compensated for by an increase in end product price, despite better quality, at least for animal feed uses. Improved quality will, however, allow cassava flour to enter other markets, for industrial or food use, in which higher prices will compensate for process cost increases.

Through allowing greater utilization of existing plant capacity (drying in rainy seasons) and permitting cassava drying to spread to regions where natural drying is not a feasible option, artificial or mixed systems may have potential. The economic feasibility of these technologies is currently under evaluation in Colombia at three sites (Sucre, Cordoba and Meta departments).

PART II: CASE STUDY: CEARÁ INTEGRATED CASSAVA DEVELOPMENT PROJECT.

INTRODUCTION

To be able to overcome the inherent market limitations caused by the lack of diversification
in cassava markets, the process of developing a market for dry cassava chips within the animal feed industry requires key institutional interventions. The Cassava Program of CIAT has been involved during the last ten years in the implementation of these type of interventions in key target cassava producing areas of Latin America. These interventions to date have been organized around the so called Cassava Integrated Development Projects.

Since May 1989, the Cassava Program of CIAT is assisting some agricultural sector agencies of the State of Ceará, Northeast Brazil in the implementation of the Ceará Integrated Cassava Development Project with financial support from the W.K. Kellogg Foundation.

This case study presents some of the main results obtained in the first two years of implementation of this project.

MACROECONOMIC ANALYSIS

Brazil is the second world's largest producer of cassava with a total production comprising almost 16% of world production and representing near 75% of Latin American production (See Fig. 4) (Anon, 1984).

Cassava is a major source of energy in Brazil. According to IBGE data, the most important energy sources in Brazil are rice, sugar, cassava, beans and wheat, all equally important. There are however, regional differences. Cassava in the North part of Brazil represents 27% of total energy intake and in the Northeast represents the most important energy source with 23% (Anon, 1924; Anon, 1984).

The market for animal feed rations

Brazil is one of the main beef producers of the world with a cattle stock of over 135 million animals (Anon, 1989). Beef and swine production is lower in the North and Northeast areas than in the rest of Brazil. Beef as well as swine production had remained relatively stable over the last 15 years. A different situation occurs with the production of poultry meat which has presented a dynamic growth within the same time frame. Brazil is the world's third largest poultry meat producer and produces some 7% of total world market supply. From the beginning of the seventies the poultry industry has been growing at an extremely fast rate and the brazilian government has made a decisive effort to open export markets. Exportation of poultry meat rose from 3.4 thousand tons in 1975 to 280 thousand tons in 1984.

Production of poultry meat in 1987 was 1.32 million tons.

Production levels of eggs in Brazil are high with a significant steady growth rate in the last 15 years. In 1987 the total production of eggs was near 25.09 billion eggs of which more than half were produced in the southeast and only 16% in the North East (see Table 3).

Demand for animal feed rations

Up to the nineteen-sixties Brazil's animal feed industry was relatively small mainly directed to dairy cattle. At the beginning of the sixties, swine production on the basis of balanced animal feed rations started to grow stimulating a fast development of the animal feed industry. The demand for balanced animal feed went from 2.4 million tons in 1971 to 10 million tons in 1985. This prompted a rapid modernization of the animal feed and meat production industry which attained similar conversion rates to those in the United States. This strong growth created an increasing demand for maize which in Brazil represents the main animal feed raw material accounting for up to 65% of the ration. Between 1971 and 1985, the consumption of maize by the animal feed industry increased from 8.4 to 15 million tons.

As a consequence of this situation Brazil which was formerly a maize exporting country had to start importing maize (between 1977 and 1980 Brazil imported more than 4 million tons). In 1986 due to adverse climatic factors, the country again had to import more than 3.5 million tons.
tons of maize.

Fig 4: Cassava Production in 1989, World and Latin America (FAO meeting jan-91)

![Cassava Production Chart]

**TABLE 3. Animal Production in Brazil by Regions**

<table>
<thead>
<tr>
<th>REGIONS</th>
<th>Cattle</th>
<th>Swine</th>
<th>Poultry meat</th>
<th>Eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>135.7</td>
<td>32.4</td>
<td>524</td>
<td>2.058</td>
</tr>
<tr>
<td>Northeast</td>
<td>24</td>
<td>8.8</td>
<td>94.8</td>
<td>329.2</td>
</tr>
<tr>
<td>Ceará</td>
<td>2.5</td>
<td>1.28</td>
<td>22.5</td>
<td>111.1</td>
</tr>
</tbody>
</table>

Source: IBGE - Anuário Estatístico 1989

**Potential for use of cassava in animal feeding**

In relation with the production and consumption levels of cassava, maize, animal feed, poultry, eggs and swine, Brazil presents specific characteristics whereby cassava production is concentrated in the North and Northeast, and maize and animal feed production are concentrated in the south and central west. These two regions produce a considerable surplus on top of their own needs. On the other hand, the northeast region has large deficit of maize as well as of animal feed (Table 4).

Macroeconomic analysis aimed at placing cassava in the overall development context of Brazil and of the northeast region with emphasis on the evaluation of the potential demand for cassava and cassava products, the ability of cassava to compete in the different markets and the production potential of cassava in different regions suggested that the production of dried cassava for animal feeding in the northeast could be an appropriate way to improve the region's self-sufficiency in feed grains, animal feed and animal production. Additionally, an alternative cassava market would be very welcome to widen the market perspectives for the
small cassava farmer with favourable effects on small-farmer income and rural employment.

**TABLE 4. Maize, animal feed and cassava in Brazil surpluses and deficit by regions (millions of tons)**

<table>
<thead>
<tr>
<th>Regions</th>
<th>Maize</th>
<th>Animal feed</th>
<th>Cassava</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast</td>
<td>-0.708</td>
<td>-0.199</td>
<td>10.245</td>
</tr>
<tr>
<td>Southeast</td>
<td>-1.212</td>
<td>-0.139</td>
<td>1.973</td>
</tr>
<tr>
<td>South</td>
<td>0.6</td>
<td>0.343</td>
<td>1.138</td>
</tr>
<tr>
<td>Midwest</td>
<td>1.559</td>
<td>0.03</td>
<td>0.947</td>
</tr>
</tbody>
</table>

*Source: Companhia de finaciamiento da produccion (CEP) IBGE, Anuario Estatlistico 1989.*

**THE SCENERY OF THE PROJECT**

**Northeast Brazil**

Northeast Brazil is a region comprised of nine States (Maranhao, Piaui, Ceará, Rio Grande do Norte, Paraiba, Pernambuco, Alagoas, Sergipe and Bahia) with a total area of approximately 1.5 million k2 (18% of country's total area).

The region is considered to be the area with the highest levels of poverty and underemployment of Brazil. Negative national records are hold in aspects such as absolute poverty, infant mortality rates, unemployment and underemployment, illiteracy and access to basic services. It has been estimated that by 1990, the total population of Northeast Brazil will be approximately 43 million representing 28% of the population of the country, that 42% of the "Nordestinos" will be living in rural areas and that over 50% of the total work force will be engaged in agricultural activities.

In northeast Brazil, 72% of the total number of families is considered to be living below the poverty line. Land distribution is characterized by a great disparity; the number of farms with less than 10 ha represent 70% of the total number of farms and occupy less than 6% of the total farm area; conversely, the number of farms with areas over 100 ha represent 6% of the total number of farms and occupy more than 40% of the total farm area (See Fig. 5).

The northeast region contribution to the total Brazilian agricultural production represents about one fifth of the total value and some of the most important agricultural commodities produced in the region (sugarcane, cotton, cassava) represent a significant share of national production.

**The State of Ceará**

Ceará is the fourth largest State in Northeast Brazil with a total area of about 148,000 km². Population projections indicate that by 1990, the total population of Ceará will be of approximatively 6.4 million. Of which 36 % will be living in rural areas. Agriculture is the main economic activity employing about 56 % of the State's labour force.

**Fig 5: LAND DISTRIBUTION IN BRAZIL NORTH EAST & CEARA (Comite Mandioca Ceara)**
Average per capita income in rural areas of Ceará is one of the lowest in the Northeast of Brazil. The income distribution pattern is extremely unfair with 50% of the population (the poorest of the poor) earning less than a minimum salary (US$ 65 in January 91) and participating with only 15% of the total rent of the state. High rates of infant mortality (25 per 1,000), malnutrition and illiteracy are common major socio-economic problems in Ceará.

Land distribution in Ceará, as in the rest of Northeast Brazil, presents a highly skewed pattern whereby the number of farms with less than 10 ha represent 48% of the total number of farms and occupy only 3.9% of the total farm area. On the contrary, the number of farms with areas over 100 ha represent only 9% of the total number of farms and occupy 68% of the total area available. Some 60% of the total number of rural producers are classified as non-owners and of those considered as owners, about 40% have no legal title to their land (see Fig. 5).

**CASSAVA PRODUCTION AND IMPORTANCE**

**Brazil**

Cassava is grown in all states of Brazil. According to FAO figures, in 1989 the area planted was 1.9 million ha with a total production of 23.2 million t and an average productivity of 12.5

![Image of a graph showing land distribution in Ceará and Northeast Brazil](image-url)
t per ha. Brazil used to be the most important producer of the world but lately this position has been lost to Thailand. On a country basis, cassava holds eight place as regards to total crop area planted and seventh place regarding monetary value.

The consumption of cassava in Brazil is highest in the rural areas and is consumed in two principal forms. First, as farinha (a toasted flour) and second, as aipim or fresh cassava. Per capita consumption of farinha on a country basis is 17.6 kg/year and of aipim is 6.1 kg/year. Consumption of farinha in North and Northeast Brazil is greater at about 45 kg/year than in the south at 3.5–6 kg/year. The consumption of farinha in Brazil as a per-capita basis has declined over the last 15 years, partially due to the urbanization process since urban consumption is significantly lower than rural consumption (see Table 5).

Northeast region

Cassava is produced in the northeast region mainly by small farmers. The climatic conditions is this area are much harsher than those of other cassava growing areas of the country and, consequently, yields are lower. Data available indicates that in 1989 a total of 1.09 million ha of cassava were planted with a total production of 11.7 million tonne and an average productivity of 10.7 tonne per ha.

Most of the cassava harvested in the region is used for production of “farinha de mandioca” with smaller amounts sold as fresh cassava for human consumption and minimal quantities used for animal feeding.

The State of Ceará

Production of cassava in the State of Ceará represents one of the main agricultural activities. During the period 1985–87, the average annual production of cassava was of 113,035 ha with a productivity level of 9.6 tonne per ha. This production represented state wide, the fifth place in terms of total crop area planted and second place in terms of total monetary value.

Consumption of “farinha” in Ceará is done mainly in the form of farinha (64 %), animal feeding at farm level (25 %) and minimal quantities are used in fresh form for human consumption.

PROJECT DESCRIPTION

Project objectives and expected outcome

The project is intended to improve the welfare of the rural poor involved in cassava production in communities throughout the State of Ceará, Northeast Brazil. This general objective is to be achieved through the introduction and adoption of improved cassava production, processing and marketing technology. The outcome expected of the project:

1. Generation and testing of a small scale cassava-based agroindustrial development model.

2. Institution building through the utilization of a participative management approach for the implementation of the project at the various levels and stages. Emphasis has been placed on developing and strengthening community-based organizations.

3. Welfare improvement through the stimulation of economic development and generation of employment opportunities in rural communities in the project area.

Project activities

Implementation of the work plan has involved the following activities:
1. Selection of site for developing a pilot project.

2. Identification of local institutional capacity to carry out the implementation of the project, as well as identification of local sources of financial support.

3. The design and establishment of the pilot project.

4. Observation of the operation of the pilot project and in situ modification of the modus operandum to accommodate it to local conditions.

5. Monitoring of project performance and modification of project design.

6. Expansion phase to semi-commercial and commercial-scale production.

PROGRESS TOWARDS PROJECT OUTCOMES

Following is a report on the progress made during the first two years of implementation of project’s activities.

Selection of site for developing a pilot project

The selection of the State of Ceará as the site for the pilot project was strongly influenced by prior involvement of some agricultural institutions of Ceará, especially the Technical Assistance and Rural Extension Agency (EMATERCE), in the promotion of activities related to small scale cassava farming and processing.

The concept of cassava-based, small scale agro-industries for the production of dry cassava chips for animal feeding was tested out between 1981 and 1987 with rather disappointing results. Among the reasons for this failure could be mentioned the extensive drought that hit the area between 1979 to 1983, the agro-industrial model chosen which relied on large producer cooperatives (400–500 members) and the poor selection of areas and farmers group.

In 1988, the Ceará State Cassava Committee was formed and in 1989, with the approval of the Kellogg Foundation founded project for Ceará, the coordinating activities by the cassava committee in support of the cassava crop in the state were strengthened and during this period (1988–1990) a total of 33 groups of cassava producers have been organized for the installation and administration of dry-cassava processing agro-industries.

The involvement and the commitment of some agricultural sector agencies in support of cassava production and processing activities during the period 1981–88 served indeed as a foundation of both experience and organizational infrastructure on which the Kellogg financed project started to be built.

Identification of local institutional capacity and local sources of financial support

The identification of local institutional capacity and the building of local institutional support is being pursued at four different levels: State, Regional, Municipal and Community level (see figure 6).

The Design and establishment of the pilot project

The establishment of the pilot phase of the project has involved activities in the following areas: production technology, processing technology, commercialization, organization and training.

During the first year (1989–1990) with 12 farmer groups, the total output was 702 t of fresh...
cassava processed and 265 t of dry cassava chips produced. In the second year (1990–1991) with participation of 32 groups the total output was 3.315 t of fresh cassava and 1.254 t of dry cassava chips. This production represented an increment of 370% in relation with the first year. A conversion rate of 2.64 was satisfactory.

Most of the dried cassava produced in Ceará has been sold directly to dairy farmers in the vicinity of the drying plants. Of the 115 consumers of the dry cassava processed in 1989, only 6 were high volume consumers although they purchased 30.4% of total output. For 1990 season the tendency appears to be the same with a large number of low volume consumers (223) purchasing 24.7% of the total output and a small number of high volume consumers (10) purchasing 75.3% of the dry cassava produced. This situation may be due to the fact that animal feed manufacturers are usually high volume consumers over prolonged periods and the project is not yet sufficiently developed to stimulate the interest of these buyers (See table 6).

Monitoring and evaluation

Tracking progress towards achieving project specific objectives is being done through an evaluation strategy which includes the following activities:

i. Monitoring the daily running of the project in the area of cassava processing.

ii. Monitoring the impact of the project in relation to cassava production and productivity in Ceará and,

iii. Monitoring the distribution of the benefits of the project among intended beneficiaries.


The following information has been collected during the first two years of processing activities in relation with the benefits of the project and its distribution among beneficiaries.

Cassava sales

During the first processing season (July-December 1989) 53% of the cassava roots processed was coming from non-members around the processing units and 47% from the members. During 1990, partial information available at this point indicates that 56% of the raw material processed was coming from non-members and 44% from members.

Fig6: CEARA INTEGRATED CASSAVA DEVELOPMENT PROJECT ORGANISATIONAL STRUCTURE
In relation with the land tenure status of the farmers, during the first year 69% of the cassava roots sold to the processing units were coming from small holders, 22% from renters and 9% from share-croppers. Information about 1990 processing season indicates that 66% of the raw material sold to the drying plants was coming from small holders, 30% from renters and only 4% from share-croppers.

Cassava processing wages

Besides the selling of cassava roots another form of benefit gained by the farmer members of the cassava agro-industries is represented by the wages paid at the cassava drying plants during the processing activities.

During the first cassava drying season (1989) the wages benefiting the farmers were distributed as follows: 52% were gained by small holders, 35% were gained by renters and 13% were distributed among sharecroppers.

Data for the second cassava drying season (1990) were only partially available and the results obtained show that 26% of the wages paid at the cassava processing plants were gained by small holders, 53% was gained by renters and 21% was distributed among share-
croppers.

Total incomes

Benefits gained by farmer groups who participate in dry-cassava processing activities include cassava sales, wages and the sharing of annual profits among members. During the first processing season, 58% of the total income earned by the processing groups went to small holders, 32% to renters and 10% to share-croppers. Total information about the second processing season is not yet available because some of the agro-industries will be processing dry cassava until January 1991. Preliminary information indicates that of the total incomes gained by the beneficiaries of the project, 53% went to renters, 25% to small holders and 22% to share-croppers.

Additionally, the distribution of this total income according to the size of cassava plots planted in 1989 shows that more than 70% of the total income went to those farmers whose area planted was between 1.0 and 2.0 hectares of cassava and that those farmers with more than 3.0 hectares received less than 10% of total income. In 1990, with partial information the results show that 94% of the total income went to those farmers with cassava areas of up to 2.0 hectares and that those farmers with more than 2.0 hectares of cassava received less than 10% of total income.

Prices of dry cassava and cassava flour

Throughout the 1990 cassava processing season (July-December) the prices for dry cassava chips have been consistently more profitable than those for cassava flour.

This situation is reducing the drastic fluctuations on cassava prices at the farm level. During this season, the incipient dry-cassava market has been acting as a floor price in the main cassava growing areas of the State of Ceará (See table 7).

| TABLE 7. Dry cassava and cassava flour prices in Ceará (Average 1990 Processing Season) |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
|                                  | Dry cassava     | Cassava flour   |
|                                  | Cr$/kg | %    | Cr$/kg | %    |
| Raw material                    | 6.53   | 52.5 | 10.89  | 64.4 |
| Processing costs                | 0.83   | 6.7  | 6.32   | 37.4 |
| Fixed costs                     | 1.20   | 9.7  | 2.40   | 14.2 |
| Selling price                   | 12.44  | =    | 16.91  | =    |
| Profits                         | 3.88   | 31.1 | -2.70  | -16.0 |

SUMMARY AND CONCLUSIONS

The experiences accumulated to date in Colombia, Ecuador, Brazil and other countries indicate that an integrated approach towards the development of the cassava crop leads to country wide benefits in terms of import substitution and the creation of employment in rural areas.

The main strategy in the implementation of cassava-based development projects lies in the transition of cassava from a basic staple food into a multiuse carbohydrate source, a process in which it is necessary to link the small-scale farmer to expanding alternative markets thus offering the possibility of generating income and employment opportunities to the small farm sector, generally responsible for cassava production in Latin America.

The abilities of the cassava crop to substitute for feed grain imports, to supply calories to the poorest sector of the society, to increase incomes for small farmers with marginal land resources and to provide employment in processing activities convert the cassava crop into
an efficiently agricultural policy instrument.

In Northeast Brazil the development of a dried cassava industry for animal feed purposes has great potential for diminishing the need to import maize, stabilize cassava on-farm prices and greatly expand the market size for the crop.

The initial results obtained in the Ceará Cassava Project are showing that linking small-scale cassava farmers usually producing in marginal agro-climatic zones to a growth market such as the one that exists for dried cassava, could yield significant increased income to this farming sector traditionally left out from the development process.

Bibliography


