PRODUCTION AND MARKETING OF CASSAVA FLOUR IN COLOMBIA

FINAL REPORT

EXPANSION PHASE
(JANUARY 1992 TO APRIL 1995)

A PROJECT FINANCED BY IDRC

PARTICIPATING INSTITUTIONS:

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT)
UNIVERSIDAD DEL VALLE (UNIVALLE)
FUNDACION PARA LA INVESTIGACION Y EL DESARROLLO DE TECNOLOGIAS APROPIADAS AL AGRO (FUNDIAGRO)
FONDO DE DESARROLLO RURAL INTEGRADO (DRI)

EDITORS: C. OSTERTAG AND R. BEST

JULY 1995

PRODUCTION AND MARKETING OF CASSAVA FLOUR IN COLOMBIA

FINAL REPORT

EXPANSION PHASE
(JANUARY 1992 TO APRIL 1995)

A PROJECT FINANCED BY IDRC

PARTICIPATING INSTITUTIONS:

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT)
UNIVERSIDAD DEL VALLE (UNIVALLE)
FUNDACION PARA LA INVESTIGACION Y EL DESARROLLO DE TECNOLOGIAS
APROPIADAS AL AGRO (FUNDIAGRO)
FONDO DE DESARROLLO RURAL INTEGRADO (DRI)

EDITORS: C. OSTERTAG AND R. BEST

JULY 1995

CONTENTS

EXECUTIVE SUMMARY

This report presents the activities of the Expansion phase of this project, conducted from January 1992 to April 1995, which centered on solution of constraints related to the processing system and on activities to facilitate the future expansion of the rural agroindustry. The achievements in each of the project objectives are as follows:

Objective I. To achieve a profitable operation of the pilot plant

Activities resulted in an efficient processing system that greatly lowered production costs. Drying time and costs were reduced, which had a positive impact on microbiological quality of cassava flour. Another important achievement was the improvement of the small-scale milling system for dry cassava chips, which allowed commercialization of flour in local markets. A carefully analyzed weekly schedule of processing operations also enhanced the efficiency of plant operation. In addition, process control parameters were established and evaluated for all operations.

Although profitability of cassava production remains relatively low, the causes are now unrelated to the processing system, but to external factors such as a high cost and deficient quality of the raw material and low prices of products competing with cassava flour. The convenience of using a computerized financial model of the business activity was amply demonstrated. This model was critical for supporting decision-making throughout the project.

Objective II. To advance the plan for expansion of cassava flour agroindustry

An important attainment in marketing was the penetration of the meat-processing and adhesive markets. However, the large real price reduction of wheat flour caused by the open market policy hindered sales expansion. In addition, the project was unprepared to confront the commercial challenge due to initial problems with flour quality and a general lack of technical expertise to support product development and assistance to clients.

Operational and management reference manuals were developed, directed to heads of production and plant managers respectively. In addition, two videos, one describing the production process and the other promoting the cassava flour agroindustry, were developed. The pilot plant was redesigned with the collaboration of UNIVALLE Architecture students to improve functionality and reduce costs. Criteria used for site selection of cassava flour plants were revised to incorporate project experience.

Project replication is being promoted by the Colombian government in the Atlantic coast with a budget of Col$180 million. A farmer cooperative in the Dept. of Santander is also executing a cassava flour project.

Objective III. To study the variables affecting cassava flour quality

An UNIVALLE professor, with the support of CIAT and NRI, is finishing a doctoral thesis in England focused on studying the influence of variety and processing on cassava flour and starch properties.

Objective IV. To disseminate information on cassava processing technology

An international cassava flour and starch meeting, organized by CIAT and

CIRAD, was held in January 1994. The event, divided in six sessions with 50 speakers and 40 posters, involved more than 130 participants from 30 countries. CARITAS and IIAP are promoting the cassava flour agroindustry in the Amazon region of Peru by means of the establishment of six pilot plants. In Ecuador, a cassava flour market study was conducted by FUNDAGRO, an NGO, in support of activities of UATAPPY, a small farmer association.

Objective V. To study effect of free market policy on wheat and cassava

Studies conducted by the Cassava Economics section indicated that the free market policy has resulted in a 70% decrease in real prices of wheat in the last three years. The cassava flour agroindustry must reduce production costs if it is to survive.

Conclusions and recommendations

* Project feasibility is uncertain due to the high cost and deficient supply and quality of cassava roots in the region, and to the insufficient entrepreneurial capacity of the executing cooperative.

* The chief achievement of this project has been the development of an efficient small-scale cassava flour production system.

* Although current market demand is almost equivalent to current plant capacity, project expansion is still not justified by market demand.

* It is recommended that the plant operate only during the root harvest period from December to April to enhance its profitability.

* Cooperative members have been trained to manage the plant, but the priority is to improve the raw material used in the plant, including industrial varieties.

* A conclusion relative to the planning of rural agroindustrial projects points to (i) the importance of the integrated, or entrepreneurial, approach encompassing interventions in production to guarantee a sufficient supply of low-priced, quality raw material, (ii) the need to assign enough funds and time for product development and marketing, and (iii) the convenience of identifying project executors with entrepreneurial abilities.

NOTE: **Cost and price information in this report is in Colombian pesos. The table below presents pertinent exchange rate information (Col$ to US$, quarterly averages).**

Year	Quarter			
	I	II	III	IV
1992	638.6	659.5	698.7	721.3
1993	753.1	778.4	802.9	810.6
1994	817.9	834.3	821.1	835.1
1995	863.3	880.3	--	--

BACKGROUND

The urbanization process of the last 40 years in Latin America has generated changes in eating habits: the rural starch staples such as maize, plantains, and root crops have given way to more convenient foods such as rice and wheat-based processed foods such as bread and pasta.

Although cassava is well adapted to the tropics and is an efficient producer of carbohydrates, the urbanization process has hit market demand due to the crop's rapid perishability and bulkiness which renders the crop expensive and with quality problems in the urban context.

Cassava is grown mainly by small farmers in Latin America, usually under marginal edaphoclimatic conditions and in association with other crops such as maize. Due to the inelastic demand in the urban market for fresh roots, the main market, improved production technology will not impact on the small farmers' income unless new markets for cassava products are identified and developed.

A new product in Latin America, dry cassava for animal feed, has been developed in Colombia, Brazil and Ecuador, through collaborative projects between national programs and the Centro Internacional de Agricultura Tropical (CIAT).

Furthermore, cassava can be processed into a high quality flour to be used as a partial or total substitute for other flours and starches in cost-reduced formulations. Because cassava is produced mainly by small farmers, previous large-scale projects have failed mainly due to lack of sufficient raw material. The current strategy is to create small cassava flour plants in areas where cassava is an important crop, with the added value remaining mainly in the rural area.

The linkage of cassava production with substitution of flours in growing markets can provide a price floor for cassava and an opportunity to expand production and income of small producers.

CIAT has developed a methodology for the design and implementation of Integrated Cassava Projects encompassing production, processing and marketing of cassava in a country or region. The methodology comprises the following phases (Pérez Crespo, 1991):

(i) Macroplanning at the national level, in which one or more cassava products with market potential are identified, followed by

(ii) Microplanning, to characterize regions selected for their potential for cassava production and the establishment of cassava-based agroindustry,

(iii) the Pilot phase follows, in which small-scale semi-commercial activities are executed,

(iv) Commercial expansion, where market consolidation for the new agroindustry is pursued.

Within the integrated project framework, one can distinguish four product development phases for each potential cassava product,a s follows:

(i) identification of product opportunities

(ii) the Research phase, in which processing technology is generated and a more profound analysis of marketing opportunities is carried out

(iii) the Pilot Project phase,including market testing, where the product is produced and marketed on a small scale under real market conditions, and

(iv) the Commercialization phase, when the market for the new product is consolidated and processing units are replicated.

All of the activities included in this methodology correspond to the production, processing and marketing functions. Phases (iii) and (iv) of product development correspond to and are best carried out within the context of phases (iii) and (iv) of the Integrated Project methodology (Wheatley et al, 1995).

Evolution of the cassava flour project

After identifying the opportunity for the product "cassava flour", product development continued with the Research phase, whose main objective was to determine the technical and economical conditions required for the development of the rural cassava flour agroindustry. Phase I included studies of cassava production systems and marketing in the Atlantic coast of Colombia, on-farm trials with the improved cassava production technology, economics studies of the milling and bread-making industries, the development of a small-scale processing plant for the production of high-quality cassava flour, and laboratory and consumer acceptability trials for bread-making products made with composite flour. This phase was executed by CIAT, the Universidad del Valle (UNIVALLE) and the Instituto de Investigaciones Tecnológicas (IIT).

In summary, the process designed comprises the following steps: selection and preparation of cassava roots, mechanical washing, chipping, artificial drying, premilling and sieving, and packaging.

The results of this work indicated that, under the prevalent price and cost structure of cassava and wheat in Colombia, it was economically feasible to produce cassava flour at a competitive price versus wheat flour. Consequently, it was proposed to continue with Phase 2 or the Pilot Project phase (CIAT, 1988).

It is important to note that, in the Research phase, the main market was considered to be the bread-making category, where 15% of the wheat flour would be substituted with cassava flour. However, because the breadmaker perceives a high risk of impairing his product quality when using cassava flour, it was decided to focus Phase 2 towards other food categories where cassava flour would not offer functional disadvantages.

Phase 2 or the Pilot Project phase, executed by CIAT, UNIVALLE and the Integrated Rural Development Fund (DRI), attempted to integrate the production, processing and marketing components of the cassava flour system under the real socioeconomic conditions of a cassava-growing region. Chinú (Dept. of Córdoba) was the site chosen for the pilot plant built with an annual capacity of 180 tons. Market studies indicated the potential use of cassava flour in multiple food categories, including processed meats and sweet cookies or biscuits. The dry chips produced in Chinú were milled and marketed in Medellín. The creation of an in-plant milling capacity was deemed convenient to penetrate local markets.

However, the consensus at the end of the pilot phase experience was that required plant investment and cassava flour production costs were too high and that cassava flour quality had to be improved in order to facilitate its marketing (CIAT, 1992). Thus, the Third phase started with a still unproven pilot plant, and the main tasks during 1992 were to solve the quality problem, achieve commercial sales of the flour, and demonstrate the feasibility of the project.

Since mid 1991, considerable research support was received from the Natural Resource Institute (NRI) with respect to flour quality. Beginning in 1993, a complementary NRI-funded research project was based at CIAT for two years which continued to provide technical support in the area of flour processing and quality.

The main objectives of Phase 3 or Expansion phase were (a) to improve pilot plant profitability, (b) to improve critical aspects that will facilitate agroindustry expansion in Colombian and in a wider international context, (c) to understand factors affecting cassava-four quality and their relation to end-product quality.

In general, most of the Expansion phase objectives were met, as the overall processing system was perfected and process control parameters were established and evaluated. The drying operation, one of the greatest limitations during the Pilot project phase, was greatly improved in relation to time and costs. The reduction in drying time had a decisive impact on microbiological quality of the flour.

Another predominant achievement of this project was the design, operation and evaluation of a small-scale milling system for dry cassava chips. Aside from the technical challenge, this accomplishment allows marketing of flour in local markets.

Although the project made great strides in the field of marketing and product development, there is still work to be done. An important achievement, however, was the penetration of the meat-processing and adhesives markets and the development of different flour qualities for each market.

An alternative operational scheme was proposed to enhance the profitability of the pilot plant, in which cassava flour production is concentrated in the five-month period when the supply of roots is high. This plan, proposing both artificial and natural drying, results in a greater FRR but requires a more intensive cassava production process.

OBJECTIVE 1

To convert the pilot plant into a commercial operation and to enhance its FRR by testing and adapting in-plant, small-scale milling operations, reducing drying costs, improving microbiological quality and expanding capacity.

1. Pilot plant operation

Before describing operational activities, it seems convenient to describe the cassava root supply situation. Since 1993, there have been serious constraints to production, such as lack of credit for small farmers, drought and bacteriosis. These factors, coupled with the increase in demand from the Andean fresh market (Medellín) and the growing local starch agroindustry, have resulted in high root prices in 1995 ($100-$110/kg) which has virtually paralyzed the cassava agroindustry in the Atlantic coast region.

In 1994, for example, the area planted in cassava in the Dept. of Sucre decreased from 22.000 to 11.000 hectares, mainly due to a lack of credit. However, this situation can be considered temporary and should normalize in the near future with the injection of sufficient credit for small cassava producers in the region.

Year 1992

In 1992, the pilot plant operated during the months of June, July, September, October and December. Operation in December, when the new root price was established and supply increased, is analyzed separately (CIAT, 1992; CIAT, 1993).

Processing in the June-October period was used to evaluate the reforms that had been executed in the drying system to reduce drying time. Nineteen lots representing 25.558 kg of prepared roots were processed. Roots, with a relatively high moisture content, wee purchased at $30/kg. A total of 7.780 kg of dry chips were produced with a conversion factor of 3.285. Roots came from the Chinú area, mostly sold by COOPROALGA members. Time between root harvest and drying was controlled to minimize the risk of root deterioration; it remained between 10 and 20 hours.

For the first five lots, the percentage of rejected roots in the root preparation operation was near the norm (5%), but afterwards it increased significantly when root preselection was transferred from the farm to the pilot plant.

In December, eight lots involving 16.660 kg of fresh roots were processed to produce 5.681 kg of dry chips, or a conversion factor of 2.832. Capacity utilization was a low 40% because production was delayed by a damage in the well pump caused by sand abrasion. Fresh roots were supplied by the Chinú area and the price increased from $30 to $32/kg. The roots were only seven months old.

In-plant selection of roots was performed. Roots were spread on the floor where small roots and trash were separated from large, healthy roots suitable for processing. Selected roots were subsequently sorted on the metal tables. Both operation demand 4 to 5 workers. Labor requirements increased 30% above the norm of 20 man-hours/ton of dry chips. This increase may also have been due to the large proportion of small roots.

Year 1993

This year, final adjustments were made in managing the processes in the pilot plant. In January, 8 lots were processed using the maximum daily capacity of the plant, for a total of 7 tons of flour. Monitoring of all control parameters demonstrated that they have been fully met. In addition, classification of the roots on the table versus on the floor was compared. The former option required 10% less labor and was less tiring. It was demonstrated that a six-man team, involving a head of production and 5 workers, could handel all operations including milling (CIAT, 1994).

The Servicio Nacional de Aprendizaje (SENA), the government training agency, programmed a training workshop on operating and maintaining plant equipment, which was implemented with all plant personnel at the end of January. In February and March, formats for gathering process data were simplified and other formats were developed.

As of June, operation of the pilot plant was turned over to FUNDIAGRO, a NGO from the Atlantic coast formed mainly by ex-employed of the Cassava Utilization section. The advisor financed by the project was transferred to FUNDIAGRO to guarantee the continuity of plant technical supervision.

<u>Year 1994</u>

In the first semester (March-June), 95.087 kg of cassava roots were purchased, but 31.7% (30.105 kg) were discarded in the selection process due to their small size. This left 64.982 kg of roots to be processed into 16.223 kg of cassava flour with a conversion factor of 4.005. Root supply decreased significantly in March and therefore capacity utilization was low. Root quality was deficient, raising the conversion factor above the expected value of 3.5. TABLE 1 and TABLE 2 present the control parameters for the production of cassava flour with artificial and natural drying respectively (Viera, 1994).

TABLE 1. **Control parameters for cassava flour production: artificial drying**

Parameters	Unit	60 mesh	100 mesh
Conversion factor (root:flour)	ton	3.5	3.7
Labor consumption	man-hour	80	89
Coal consumption	kg	650	720
Electricity, consumption	kW-hr	160	178
Water consumption	m^3	10	11
Sacks	40 kg	25	25

Due to the negative profitability caused in by low wheat flour prices and deficient raw material quality, two processing options were tested to adapt quality requirements to the client's need and thus reduce production costs. The first option consisted in drying naturally for markets where microbiological quality was not an important variable. It was implemented successfully for the adhesive and meat-processing markets. The second alternative embodied the production of finer flour, especially for the

TABLE 2. **Control parameters for cassava flour production: natural drying**

Parameters	Unit	60 mesh	100 mesh
Conversion factor (root:flour)	ton	3.5	3.7
Labor consumption	man-hour	110	122
Coal consumption	kg	0	0
Electricity, consumption	kW-hr	86	95
Water consumption	m^3	10	11
Sacks	40 kg	25	25

adhesives market by utilizing the 100-mesh instead of the 60-mesh screens.

In 1994B, the plant operated in July, August, November and December. for analysis purposes, two periods are distinguished, July-August (B-1) and November-December (B-2), because supply of raw material and operations varied significantly. In both periods root supply was low. In the B-1 period, 37.585 kg of selected roots were processed, while in B-2, the figure was 41.580 kg of unselected roots. It must be noted that, as of B-2, income from dry chips derived from rejected roots was retained by the pilot plant (Viera, 1995).

A total of 17.9 tons of 60-mesh cassava flour was produced in the semester, 10.3 tons in B-1 and 7.6 tons in B-2. From this volume, 7 tons of 100-mesh flour and 10.8 tons of 60-mesh flour was obtained; losses amounted to 47 kg. Other by-products obtained were 5.95 kg of bran and 2.56 tons of dry chips.

The conversion factor in B-1 was 3.65 (**selected roots to cassava flour**). In B-2, the method for calculating the conversion factor was modified. This ratio is now calculated as **unselected roots to cassava flour** and during B-2 was 5.5. This means that the financial model considers both the cost of all roots, selected and rejected, and the income of all products and by-products, such as bran and dry chips.

The capacity utilization rate was 35%; 28 lots were processed, and 15 were sun-dried in cement floors. Sun-dried flour exhibited good physical and chemical quality.

A two-day training workshop, directed to plant managers and workers, was conducted and focused on the following topics: administration, financial statement analysis, production costs and organization. Additionally, the functions of the manager and head of production were revised.

Give the low profitability of the pilot plant, an alternative operational scheme was proposed in which the same 200 tons/year of cassava flour are produced during the five-month period when root supply is high. This plan, proposing both artificial and natural drying, results in a greater FRR but requires a more intensive production process (See Section 6 of Objective 1).

In preparation for the execution of the above mentioned plan, a single screen mill was installed beginning 1995 to increase milling capacity. Additionally, another washing machine was coupled to the existing one to double the capacity of this operation, one of the main bottlenecks for capacity expansion of the process.

It can be concluded that the objective regarding the design of a practical processing system and the efficient operation of the pilot plant has been fully met. All of the process control parameters have been established and evaluated.

2. Production costs

The average variable cost per ton of dry chips for the 1992 June-October period was high, $190.959, due mainly to the low loading density, an elevated root-to-chip conversion factor and high coal consumption. However, for the three lots of September, this figure was low: $144.550, which can be explained by the low conversion factor. Furthermore, variable costs of production were lower in December ($155.245/ton of dry chips) than in the previous period, mainly because the conversion factor declined (3.285 to 2.935), as well as coke consumption (980 to 551 kg/ton).

In 1994A the variable costs were $246.638/ton nd fixed costs were $57.942/ton, for a total of $304.580/ton of cassava flour. The weighted sales price, referring to one ton of flour plus the income from bran, was $247.445/ton.

In 1994B, two periods are distinguished: July-August (B-1) and November-December (B-2). Production costs in B-1 were $279.972 and $358.069 in the second period, both referring per ton of 60-mesh cassava flour. Production costs for the second period are higher because it incorporates the cost of rejected roots. The weighted-average sales price was $271.316 for B-1 and $336.610 for B-2, expressed also per ton 60-mesh flour and including the income from by-products.

The financial model (See ANNEX 1) indicates that cassava roots accounts for 64% of the production cost of cassava flour and its by-products.

In conclusion, one of the major constraints for profitability and competitiveness in cassava agroindustry is the lack of roots with high dry matter content.

3. Cassava chip drying system

The drying infrastructure was modified from March to May 1992 with the main purpose of reducing drying costs. Reforms were very effective in reducing drying time by 50%, which in turn improved the microbiological quality of the end product, cassava flour.

The drying zone was isolated with walls to avoid dust and animal contamination, and the drying area was expanded: two adjacent 3 x 7 meter chambers were built. The purpose of this proportion was to improve airflow distribution in each chamber. In March, the coal burner was modified by placing a two-inch thick isolation layer of refractory cement in the combustion chamber for a more efficient combustion, a higher drying temperature and the capacity to use mineral coal. Also, another metal burner was purchased, and both burners were connected in parallel to the first chamber. The cost of these reforms and the new burner was Col$4.500.000 (April 1992).

The drying operation required three workers for loading, turning, handling of the burner and drying control, and for unloading. In December, the two coke-fired burners reached temperatures above 60℃ after two hours of initiating the drying process. Coke consumption declined significantly because the second burner was insulated.

Loading density was varied to measure the effect of this variable on drying time and coke consumption. Due to electrical rationing, day and nighttime drying was conducted. The exceptionally high moisture content of roots increased coke consumption and drying time. A strong relation was noted between loading density and drying time and, to a lesser extent, between loading density and coke consumption. The remaining factors do not correlate significantly with coke consumption.

Drying homogeneity was observed; little variations were noted in air velocity above the perforated floor in different points of the drying chamber. This confirms that a 2:5 width-to-length ratio allows an adequate airflow distribution in the drying chamber.

In 1993, given that drying time had been reduced by 59%, the labor parameter was revised and set at 20 man-hours per ton of dry chips.

Due to high costs and deficient quality of coke and the urgent need for a reduction in production costs, it was decided to evaluate coal from the Dept. of Cesar as a fuel source. Six trials were conducted with a low loading density (50 kg/m^2) and drying temperature from 60-65°C, demonstrating that coal was in fact a better alternative than coke from the Dept. of Cundinamarca; although consumption was similar (500 kg/ton of dry cassava), coke was much more expensive (Col$94/kg versus $24/kg).

In 1994, part of the cassava flour produced was derived from sun-dried cassava chips, to reduce costs. This flour was destined to clients in the adhesives market for whom the microbiological quality of the product was not a critical factor.

It can be concluded that the drying operation, one of the greatest limitations during the pilot project phase, has been greatly improved in relation to time and costs. As already mentioned, the drastic reduction in drying time also had a positive impact on microbiological quality of the flour.

4. Cassava flour quality

In 1992, the microbiological quality of cassava flour improved significantly, especially as regards to mesophile and coliform counts, because all of the lots complied with wheat flour norms. It was considered that progress was due to these three factors: (a) drying time reduction from 22 hours in 1991 to 8-13 hours in 1992B, (b) a decline in the time between harvesting and drying, from 36 to 20 hours, and (c) quality control of the fresh roots purchased. The high yeast and fungi counts may have been due to sample contamination in the laboratory during delays caused by electrical rationing. Total cyanide content of chips was slightly above the 50 ppm limit for human consumption.

<u>NRI technical support</u>

This project started out with a visit by NRI scientists in 1991 to assist with technical problems encountered in the pilot plant. It was designed to complement the CIAT/IDRC project, and to take it a stage further. The project was funded by the Overseas Development Administration (ODA) and managed by NRI. An NRI engineer was placed at CIAT from January 1993 for a period of two years.

In 1992, NRI provided technical assistance to study ways of improving microbiological quality. The following work was carried out:

- prewashing and holding trials that did not indicate a clear-cut impact of these treatments on the microbiological quality of the final product. It was also verified that the microbiological count goes down with storage.

- trials to research the impact of washing and drying variables on the microbiological quality of the dry cassava chips. Four drying trials were conducted to investigate the impact of loading density, air flow and temperature on drying time, microbiological quality and cyanide content. It was concluded that a reduction in loading density caused a decrease in drying time, thus improving microbiological quality. However, drying efficiency was unfavorably affected.

- Six trials: (i) three to study the effect of root harvest time and nighttime holding conditions, under water or dry, in microbiological quality, and (ii) another three trials to examine the impact of applying hypochlorite acid to the washing water on the microbiological quality of the dry chips. The washing trials indicated that holding under water was better than dry holding relative to chip quality; it was also important to acidify the water with chloride. The use of a solution with a high chloride concentration after washing did not have the expected consequence.

- Another trial suggested by NRI (i) measured the effect of holding the roots in sisal bags or under water, and (ii) compared the effectiveness of two microbicides, sodium hypochlorite and TEGO, a local product. The results indicated that neither treatment was effective in controlling aerobic mesophylls and total coliforms simultaneously, although TEGO did control mesophylls.

- Another trial compared the normal process at the pilot plant with three additional treatments, as follows: (i) nighttime silage of moist chips, (ii) immersion of fresh roots in a concentrated solution with hypochlorite acid prior to chipping, and (iii) fermentation of fresh chips under water. The data demonstrated that the normal process resulted in the best microbiological quality while fermentation facilitated the elimination of total cyanide.

Research carried out in 1993 (Jones, 1995) indicated that modifying the chips used in the production of cassava flour could increase the level of cyanogen elimination during processing. Rasping of the roots to pulp, as used in cassava starch extraction, was also shown to increase cyanogen elimination over chipping.

Preliminary research of rasping of roots to pulp indicated that cyanogen elimination was increased from about 70% with chipping and drying to at least 90% with rasping and drying, regardless of rasper type or drying regime. However, this increase is achieved at the cost of increased microbiological load in the dried product, due to greater free nutrient availability in the pulp. The effects of pre-treating the roots on cyanogen elimination and microbiological quality were then evaluated.

The effects of identical pre-treatments and drying regimes on both chips and rasped pulp were evaluated, as follows: treatment A, washed in treated water (10-12 mg free Cl) as in the standard process, and treatment B, washed as in A, then blanched in boiling water. The results of all treatments were more marked in the chips than in the pulp, where the rasping effect of almost complete tissue disruption was the controlling factor.

Blanching of the whole roots before processing tended to shorten the drying time required, except in the case of oven-dried chips. This pretreatment also increased the level of CN elimination over standard processing, by 10% in the oven-dried chips and 3% in the pulp. The treatment of blanching is proven technology to reduce microbial loads, and gave a slight improvement in chip quality with both sun and oven drying, and similar rasped pulp quality to the control.

Peeling the roots increased the oven drying rate by 10% over the control in both chips and pulp. However, it also reduced cyanogen elimination relative to the control by 25% in the chips, and 60% in the rasped pulp leaving high residual CN levels in the dried products. Even at higher drying rates than the controls, the microbial loads in both peeled products were a factor of 10 greater. Use of the modified chipping disk with the peeled roots gave similar dried product quality, as did blanching the peeled roots before rasping. This indicates that the presence of peel has some anti-microbial effect.

The standard chipping disk used in production can be modified to produce thinner chips by adding shims between the blades and the disk, and gave promising results in 1993 trials. Using peeled roots, the oven drying rate of these modified chips was some 40% faster than the standard chips, and nearly 10% more CNs were eliminated. Microbiological quality was similar to standard peeled chips. These results confirm the potential of the modified disk, which now requires field testing under pilot plant conditions.

Blanching of the washed whole roots before rasping appears to hold out most promise for improving the microbiological quality of dry pulp.

Based on these results, a batch tray dryer has been designed that uses an existing coal-fired brick furnace. The dryer has a nominal batch capacity of 200 kg fresh chips/pulp at a tray loading density of 10 kg per m^2, and variable drying temperature, flow rate and recirculation split.

5. Cassava chip milling system

The small-scale milling system developed during the 1990-1994 period consists of a pre-grinder, a work screw, a double screen and an extraction system (fan-cyclone), operating in series (See FIGURE 1).

In 1992, this system was evaluated and modifications were executed during the first semester. The changes included redesign of the cylindrical screen structures, the width of the bottom hopper was increased and its form modified, final design of the extraction system (fan-cyclone), construction of openings for cleaning and increase in the velocity of the internal blades of the upper cylindrical screen.

The equipment was then sent to the pilot plant where it was used to process almost three tons of dry chips with an average extraction rate of 81%, similar to the one obtained in commercial wheat mills.

In September, the milling system was organized so that it could operate continuously and was used to process 1.5 tons. The performance of the double screen was negatively affected by chip

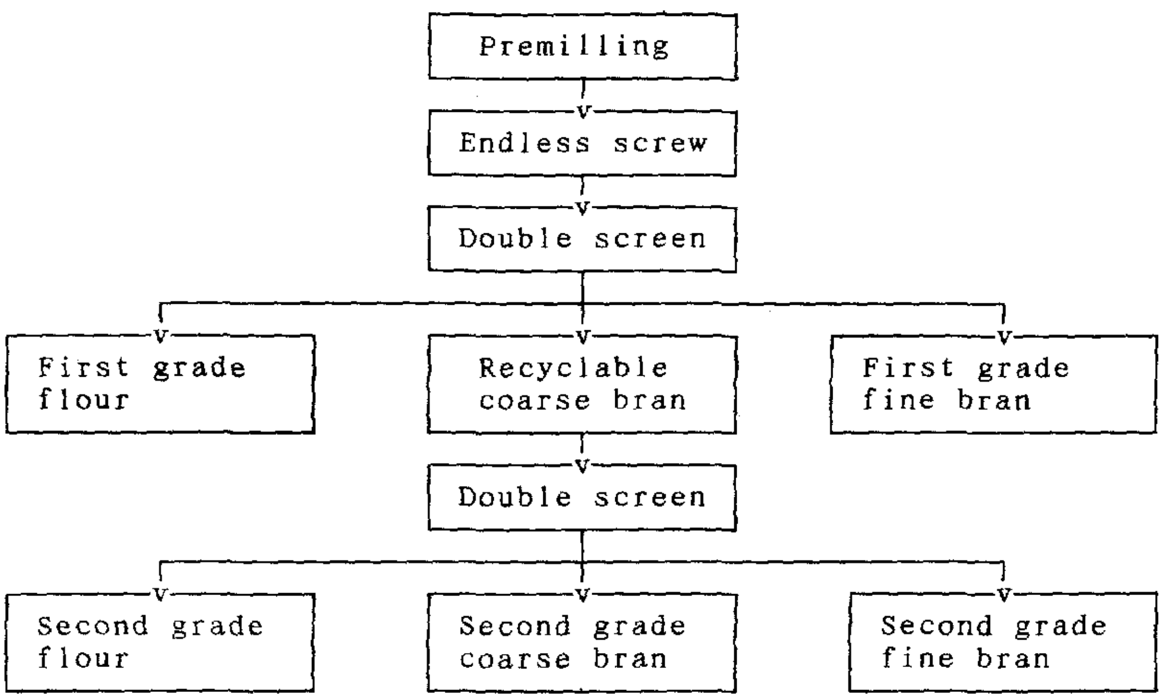

FIGURE 1. Diagram, including products and by-products, of the cassava chip milling system

moisture above 12%, resulting in an extraction rate below 40%. The stainless steel screen of the lower cylinder, with 25 µm-holes, ruptures frequently due to the recurrent contact with the external wire mesh and, therefore, a denser wire mesh was used to provide greater support to the steel screen. This modification was very effective.

Although flour extraction increased to 60%, it did not reach the expected level. Based on past experience, it was notices that both the coarse and fine brans still contained removable flour, especially the latter which represented 32%. This was corroborated afterwards at CIAT, where the first-grade fine bran was reprocessed three times in a cylindrical screen and 17% of the original chip weight was recuperated as flour. In addition, 5% of the original weight was recovered as flour, after remilling the second-grade fine bran. This means that, under optimal conditions, the extraction rate in December at Chinú would have been above 80%.

The original low extraction rate was due to the moisture content above 13% and the high fiber content of the roots.

Particle size analysis indicated that 90% of the particles had a diameter below 100 µm. This means that cassava flour has finer particles than wheat flour, which exhibits only 60% of the particles below 100 µm.

The lower cylindrical screen was the component limiting the system capacity to 250 kg of chips per hour, since the premilling machine and upper screen both had a throughput of approximately 900 kg/hour. Therefore, at the end of 1992, the diameter of the lower cylindrical screen was increased by 40%,from 18 to 25 cm, to double system capacity.

In the first semester of 1993, 6 tons of flour were processed: 3 tons for commercialization and three for flour evaluation in the context of a NRI/CIAT project. The performance of the milling system was satisfactory. For the first time, the double screen performed well with larger amounts of flour, solving the principal production problems occurring towards the end of 1992.

The extraction rate for high-grade flour was from 72-92%. The first value was obtained when there was no recycling of bran; when it was recycled at least twice, the percent extraction ranges from 85-93%. It should be remembered that chip moisture and varietal quality also affect the extraction rate; for example, fibrous varieties result in lower extraction rates but the effect of these factors remain to be quantified. The effective screening area of the steel mesh also affects machine performance; the greater the work area, the greater the extraction per pass, without having to recycle as much, which affects machine productivity (CIAT, 1993).

Management of air flow also affects the extraction rate. In this case, it appeared that the air flow volume was a little high, causing an average loss of flour of 5.4%. Given that only a small amount of material was used for the test run, a large amount of chips remained in the worm screw (5.8%). Under these conditions, it is assumed that the extraction rate would be 8 points higher, or 79 and 71% respectively for the two varieties tested. These values are closer to the expected levels.

Nevertheless, several secondary problems related to the design and construction of the lower cylinder remained:

- deformation of the screen because of defects in the design of the lateral cap
- deformation of the blade shaft due to its insufficient diameter
- deficient fastening of the stainless steel screen to the screen structure
- width of the internal blades
- difficulties in cleaning the equipment

In 1993B, a new lower cylinder was designed and built to correct the above mentioned problems. Additionally, the diameter was increased from 25 to 30 cm. After successful testing of this system component at CIAT, another one was built and was sent to the pilot plant.

There is still a limitation regarding the lower cylinder: the fine screen cannot be found in the local market, and local metal shops also lack the expertise to perform adequate maintenance of the equipment.

Certainly, one of the predominant achievements of this project was the design and operation of this small-scale milling system for dry cassava chips. Besides the technical challenge, this achievement allows marketing of flour in local markets and also permits to tailor flour quality to client needs.

6. Financial analysis of cassava flour production

<u>Year 1993</u>

Although the financial model (Ostertag and Wheatley, 1993) for the pilot plant was based on real data, there were still some theoretical assumptions such as the 75% capacity utilization rate. It was also assumed that pilot plant construction (excluding equipment) corresponds to the new low-cost prototype; that is, at a cost 25% less than the current infrastructure.

It is also important to illustrate how the conversion factor was calculated. The basis was the selected and sorted roots, assuming a 20% rejection rate. These roots were purchased by the neighboring drying plant at half the market price and, therefore, to calculate the conversion factor, only half the rejection rate was considered. This means that if the purchase price of rejected roots were modified, it would also affect the conversion factor as well.

TABLE 3. Parameters of the cassava flour production process in the Chinú pilot plant (October 1993)

Plant capacity, tons	180
Capacity utilization, %	75
Conversion factor (root to chip)	3.0:1
Labor, man-hours per ton of chips	70
Polypropilene sacks per ton of flour	25
Electricity, kW-hour per ton of chips	120
Fuel, mineral coal per ton of chips	500
Water, m^3 per ton of chips	7
First-grade flour extraction rate, %	82
Bran extraction rate, %	17
Milling losses, %	1

The model indicated that if the plant operated at 75% capacity, the financial rate of return (FRR) would be 26%, similar to the opportunity cost of capital in Colombia in 1993. The required investment was US$64.409. The price for flour and bran (weighted average) was Col$203.990/ton; variable costs, $149.950; fixed costs $13.950/ton; consequently, the net profit was $40.097/ton (See TABLE 3).

It should be noted that despite the fact that drying and fuel costs hade been reduced considerably and a 25% reduction in building investments had been assumed, profitability was still low. This was mostly because the remaining production costs underwent normal price increases, whereas the price for high-grade flour had remained relatively static. As explained, the reason for this wa that wheat flour prices had remained relatively stable for the previous two years as a result of the free market policy.

The strategy for increasing the FRR was as follows:

- sell the rejected roots (20%) at the market price and not 50% less as was the case. This would have a favorable effect on the conversion factor.

- if the adhesives market were penetrated, the sales price could be increased immediately, more than 10%, as cassava would compete with cassava and maize starches that are more expensive than wheat flour.

- once the market for cassava flour has been consolidated, a small additional investment, mostly in fuel burners, could duplicate plant capacity to more than 300 tons/year.

Year 1994

First of all, it should be noted that the financial model (See ANNEX 1) underwent some basic changes this year. The basis for estimating the conversion factor was no longer selected and prepared roots, but roots in general. Therefore, dry chips produced in the adjacent drying plant and derived from rejected roots was also considered as a by-product of the cassava flour process.

The financial analysis was conducted for an installed capacity of 200 tons per annum, with a utilization rate of 80% and a ten-month period of operation. Therefore, annual production was assumed to be 160 tons or 16 tons per month. Values corresponding to the control parameters were used in the model.

Production costs were estimated for an operational scheme encompassing both types of drying. Cassava flour for human consumption was dried artificially whereas flour for adhesives was sun-dried. According to current market conditions, the demand for 100-mesh flour (adhesives market) is 4 tons per month, which can be derived from 4.444 tons of 60-mesh flour. This means only 11.566 tons of flour would have to be dried artificially. This proportion was used to calculate a weighted average of the control parameters, which in turn was used to estimate production costs.

The sales price was also based on the 60-mesh flour production volume. Sales price is averaged among the different product portfolio, using proportions which are calculated as follows:

(1) of the 16 tons of 60-mesh flour produced monthly, some 4.444 tons are transformed into 100-mesh flour, generating 0.4 tons of fine bran. This by-product is mixed with the other 60-mesh flour to obtain 11.956 tons of this flour.

(2) the bran derived from the milling process to obtain 16 tons of cassava flour, assuming an extraction rate of 82%, is 3.3 tons. Milling losses represent 1%, or 0.21 tons.

(3) to produce 16 tons of flour, 80 tons of roots are required of which 16 tons of small roots, or 20% are discarded. 6.9 tons of cassava chips for animal feed are obtained from this

rejected material.

Total investment amounted to Col$52.554.150, total production costs are $311.650 per ton of flour, the weighted sales price is $344.376 per ton of flour. The prices for the different products in 1995, placed in the Chinú plant, were as follows: 60-mesh flour: $250/kg; 100-mesh flour: $310/kg; bran: $110/kg and dry chips: $135/kg. The profitability analysis corresponds to nine years and the resulting FRR was 22%.

Raw material accounts for 64% of total production costs, followed by labor (12.5%), mineral coal (6.4%), fixed costs (6.1%), etc. One of the modifications in the financial model, the inclusion of rejected roots in the conversion factor, have raised the weight of "raw material" in total production costs.

Alternative production scheme

The ten-month operational scheme assumed in this section is the one whose implementation has been attempted in this project. An alternative scheme was proposed, in which the plant operated during the five months when root supply was high and both drying systems were used simultaneously. This plan contemplates the production of 200 tons of cassava flour in the five-month period between December and April. Monthly production has to be 40 tons which means that 40 one-ton lots have to be processed. The financial model was used to estimate the FRR of this option, which was 40%. It assumes that personnel is only hired during the five-month production period.

The quality parameters for cassava roots destined for the production of cassava flour are the following:

* minimum dry matter content: 30%
* maximum content of small roots (rabos): 25%

Roots demanded per year amount to 1.000 tons, planted in 100 hectares. Monthly demand is 200 tons which means that 20 hectares are harvested monthly.

In conclusion, the advantage of using a computerized financial model of the business at hand was amply demonstrated. This model, easy to update and use, was very valuable in decision-making.

C. SPECIFIC OBJECTIVE II

To develop and execute a plan for expansion of cassava flour agroindustry in Colombia including (i) site selection methodology, (ii) low-cost redesign of the flour plant, (iii) identification of potential sites, (iv) promotion of the agroindustry, including the identification of financing sources,

(v) market development, (vi) training, and (vii) monitoring and evaluation.

1. Marketing of cassava flour

The marketing effort in Medellín during Phase 2 of this project, which focused on the food industry, was unsuccessful due mainly to the lack of technical expertise and the deficient microbiological quality of the cassava chips produced at that time in Chinú. In 1992, the installation of the small-scale, in-plant milling system enabled to concentrate efforts in the Atlantic coast region, where cassava flour could compete with wheat flour. Additionally, microbiological quality of cassava flour had improved.

Four main markets for cassava flour had been identified, as follows:

- the food industry, made up of companies in categories such as processed meats, cookies, cones, soup and sauce mixes, powdered drink mixes, etc.,
- neighborhood bakeries; through key distributors, hundreds of bakeries can be supplied with a cheaper composite wheat-cassava flour for making cookies and cakes,
- household use; cassava flour has many in-home uses (nursing bottles, soups, porridges, etc.) similar to those of wheat flour and corn starch,
- industrial companies that produce plywood or that use/produce vegetable adhesives.

Three cycles of sales visits were conducted in May, July and November. In the first visit, four meat processing companies and five flour wholesalers (including two wheat mills) were visited in Sincelejo, Cartagena and Barranquilla. The sales presentation to wholesalers emphasized the opportunity for selling a composite wheat/cassava flour to bakeries for production of sweet cookies.

The wholesalers insisted in the importance of obtaining technical and promotional assistance and in the need for attractive packaging. Recipe books were developed by the Cassava Utilization section and a professional breadmaker in Barranquilla.

In the July visit, follow-up contacts were made with three meat-processing firms in Barranquilla and one in Sincelejo and samples were supplied. The use of a composite wheat/cassava flour for pastry was recommended and recipe books were handed to bakeries.

The objective of the third visit in November was to promote cassava among companies producing spices and flour for in-home use in Barranquilla. Five kg samples were supplied. Additionally, contacts were made and samples sent to Rica Rondo (processed meats, Cali), Laboratorios Griffith (premixes for processed meats, Medellín), Noel (cookies, Medellín), and Tecnas (premixes for processed meats, Medellín) and Nestle (soup mixes, Bogota and cookies, Pereira).

Two food technology undergraduate students from the Universidad Nacional of Bogota conducted their thesis on the use of 60-mesh cassava flour in processed meats, with good results. CIAT provided background information and flour samples (Padilla and Velandia, 1993).

The main achievement in 1992 was the penetration of the processed-meat market in the Atlantic coast. In fact, two clients in Sincelejo and Barranquilla purchased six tons at $220/kg during the period from July to November 1992; another client conducted a trial and purchased 125 kg. In addition, an interest was aroused among flour wholesalers in selling composite wheat/cassava flour to bakeries for cookie and pastry production.

Other marketing variables

The price for cassava flour was established based on the production cost structure and also seeking to underprice wheat flour by 15-20%. It was also decided to adopt a flexible pricing policy for cassava flour because the price of wheat flour, the competition, varies according to geographic location and volume of purchase.

A brand name was chosen for cassava (YUKARIBE) and the process of registering it nationally to protect it from eventual competitors was initiated.

A 0.5 by 0.8 meter, 25 kg polipropylene (density 80) bag, printed in red and green was designed at CIAT and produced in Medellín. This weight was selected because the bulkiness of cassava flour made the 50 kg size impractical.

Direct distribution was proposed for large buyers, such as meat processors; for small clients such as bakeries, a wholesaler was recommended.

In 1993, the marketing component of the project was subcontracted to FUNDIAGRO; CIAT continued providing technical backstopping. It was decided to execute marketing activities in the food market of the Atlantic coast because there cassava flour could compete more favorably with wheat flour on a price basis. Given the liberation of the market economy, the price of wheat flour had remained static for the last two years.

An important flour distributor in Sincelejo expressed interest in selling cassava flour for making cookies. They later wanted to sell a composite wheat/cassava flour (70/30) for cookies, an idea that CIAT supported by loaning a mixer. Finally, the distributor dropped the idea because the cookies were too crumbly. With respect to the home market, an effort was made to sell 250 gram bags of cassava flour in Sahagún and Lorica; but for lack of a coordinated marketing action, the distributor lost interest in view of the low demand (FUNDIAGRO, 1993).

In Barranquilla, a meat-processing plant (Frigorífico Garibaldi) was interested in the flour, but in the end they did not purchase it because the microbiological quality was unsatisfactory. Samples were also given to a manufacturer of dextrins (adhesives), who found the product good if an anti-fungal preservative were added.

Given the poor results in the market for human consumption, in June the Cassava Utilization Section developed a marketing plan that pointed to the desirability of concentrating on the industrial adhesives market (Ostertag, 1993). The main reasons were that, in this market, competing raw materials such as maize starch are more expensive and microbiological quality is not a critical factor.

Consequently, a technical publication on the preparation of vegetable adhesives was translated from English and was used as reference. In August 1993, three sales people were trained and contracted to do market research and promotion during four months in Bogota, Medellín and Barranquilla; the promotion in Cali was the responsibility of the distributor. A bibliographic review was conducted on the uses of cassava flour and starch in the chemical, paper, textile and food industries (FUNDIAGRO, 1993).

Potential clients were identified, visited and were offered samples. In each city, from 1-4 industrial clients expressed interest in conducting trials. One of the main findings was that the 60-mesh cassava flour produced by the plant was too coarse for the needs of the vegetable adhesives market; therefore, the four was reformulated by using a 100-mesh screen instead, which produced a finer flour, similar to starch.

The majority of adhesives used in Bogota and Medellín are synthetic and vegetable adhesives are purchased in Cali, from Maizena (the US multinational Corn Products Corporation) mainly. In Cali, small and medium-sized enterprises producing vegetable adhesives were found. With the collaboration of CIAT and the distributor, two firms were contacted which displayed interest in experimenting with the cassava flour, one for glass labels and the other for carton cylinders and cones. The first company bought 1.5 tons but did not repeat purchase.

However, the main constraint was the lack of expertise in formulating industrial adhesives based on cassava flour. The main producers of vegetable adhesives in Cali are the Corn Products Company (CPC), a multinational, and Garcia Asociados, both of whom offer technical assistance to clients with respect to special formulations (FUNDIAGRO, 1994).

For that reason, it was decided to contract a professional to develop formulas for different end uses, such as adhesives for rolling tubes and cones, for cardboard boxes, paper bags, for paper labels, etc. (Viera, 1993). These formulas have to be tested at the industrial level to evaluate their performance and machinability.

Another factor that limited the marketing effort was the high transportation cost from the pilot plant to Cali and the inundation of the Cali market with cheap cassava starch from Ecuador.

In the first semester of 1993, cassava flour was sold to meat-processing clients in Sincelejo and Valledupar and in Barranquilla for adhesives. Sincelejo purchased 8.223 kg at \$200/kg, Valledupar 6.000 kg at \$215/kg and Barranquilla at \$260/kg; these prices correspond to the flour placed in the pilot plant.

The Barranquilla market was considered to be more promising for cassava flour and therefore marketing activities there extended until June 1994. Three market opportunities were identified, as follows: adhesives for glass labels, adhesives for agglomerates and plywood and adhesives for paper bags. Four companies were contacted that displayed interest in the cassava raw material. Samples and cassava flour-based adhesive formulations developed by the consultant were handed to them. The potential market for cassava flour in Barranquilla is estimated to be 40 tons/month, as follows: 25 tons for plywood, 15 tons for paper bags and 3 tons for glass labels. The plant is currently selling to this last category.

Towards the end of 1994, the price of the competitive raw material, wheat flour, increased for the first time in 36 months (from \$240 to \$270/kg) and as of June 1995 is near \$340/kg. This situation should be favorable for cassava flour, especially in the adhesives market. The meat processor in Sincelejo who had been buying cassava flour for the last three years is now buying low quality rice flour at a price that is 25% cheaper than cassava flour. TABLE 4 presents price information of cassava and wheat flours.

In conclusion, although the project progressed enormously in this critical area of work, it was really not prepared to confront the marketing challenge due to initial problems with flour quality

TABLE 4. **Relative wholesale prices of cassava flour (Chinú) and wheat flour (B/quilla) (Col$)**

Period	Cassava flour (60 mesh)	Cassava flour (100 mesh)	Wheat flour (1)
IIS 1991	$170		$250
IIS 1992	$220		$250
IIS 1993	$230		$250
IIS 1994			$270
IS 1995	$250	$310	$340

(1) The price of wheat flour is 5-8% higher in B/quilla than in Medellín and Cali.

and a general lack of technical expertise to support product development and interaction with potential clients. An important achievement was the penetration of the meat processing and adhesive markets and the development of different qualities for each market.

2. Processing and management manuals

Two reference manuals have been developed as an aid to cassava flour plant managers and for use in training (Alonso, 1995 and Ostertag, 1995). The operational manual is directed to heads of production and will concentrate mainly on the processing aspects, while the management manual is aimed for plant managers and will deal with general aspects of the cassava flour business.

The operational manual encompasses the following chapters: Concepts and basic definitions, Raw material, Final product, Processing, Equipment, Weekly schedule of production, Daily flow of activities, Enterprise requirements, Infrastructure, Quality control and Maintenance.

The chapters of the management manual are: Principles of administration, The cooperative enterprise, The cassava flour product system, The cassava flour production process, Administration of production, Total quality control, Simplified accounting, Costs and profitability, Marketing, and Human resource administration. Two annexes cover: Timetable for the establishment of a cassava flour plant and Design and construction of three cassava-processing plant types. Both manuals are in the final draft stage.

3. Processing and promotional videos

The development of two videos (Gonzalez et al, 1993), one describing the production process and the other promoting the cassava flour agroindustry in general, was initiated in 1993 and were ready by the first quarter of 1994. The main objective of production video is to be used for training heads of production; it describes the production process, encompassing operations, equipment, raw material and final product specifications and quality control.

The second video is promotional and is directed to government and non-government organizations, investors, and farmer organizations. It focuses on the importance of rural agroindustry, the production process and management and marketing aspects.

The development of scripts was a team effort between the Cassava Utilization and Training Materials sections. The main steps in the production of the video were the following:

- Meeting to set objectives and define basic contents
- Preparation of preliminary scripts
- Development of audio and video components of script
- Production plan
- Filming and recording
- Edition

4. Pilot plant redesign

The purpose of this activity initiated in January 1993 was to lower the initial investment required to build a cassava flour plant to improve profitability. The new design was to respond to functional and environmental conditions as well. The project was undertaken by a team of four architecture students at UNIVALLE, under the supervision of a professor and with technical assistance from the Cassava Utilization section. After two visits to Chinú and receiving feedback from CIAT and COOPROALGA, the team presented the final proposal, including plans and models, on three prototypes: a cassava flour plant, a cassava chip plant and a cassava chip milling plant. The cassava flour plant was costed out by a civil engineer from Sincelejo.

5. Site selection criteria for cassava flour plants

The list of criteria that was used for site selection of the cassava flour pilot plant in 1989 was revised to incorporate the experience obtained during the project. The criteria have remained virtually the same but they have been disaggregated to facilitate the analysis for future site selections. The new list is presented below.

The new criteria include the following: educational level and entrepreneurial capacity of executing organization, proximity to fuel sources such as natural gas and mineral coal, availability of a natural drying plant, availability of machine repair shops, quality of roots, location with respect to road system, and availability of means of transportation.

1. Human resources

   a. Stable farmer or private organizations exist in the region.
   b. At least some individuals in these organizations have highschool studies.
   c. Some individuals in the organization exhibit entrepreneurial abilities.

2. Raw material supply

   a. Cassava is an important crop in the region.
   b. Healthy large and medium-sized roots with high or normal levels of dry matter can be obtained.
   c. Price of cassava roots tends to be low.
   d. Members of the organizations own land.
   e. Access to the fresh and starch markets is deficient.
   f. Neighboring regions also produce cassava.

3. Basic infrastructure

   a. The road system allows a year-round linkage with markets and root & fuel suppliers.
   b. Water and electricity are available.
   c. Natural gas and/or mineral coal is available at a normal price.
   d. Natural drying plants exist nearby.
   e. Machine repair shops are available.

4. Marketing

   a. Markets for cassava flour are relatively nearby.
   b. The plant site is near the road system and basic infrastructure.
   c. Transportation of flour to markets is available.
   d. Adequate communication and banking services are available.

5. Basic infrastructure

   a. GO's or NGO's exist that can provide support in community organization and enterprise development
   b. GO's or NGO's are present that can supply financial services to enterprises, such as short-term credit (for working capital) and long-term credit (for processing

equipment and infrastructure)

c. GO's or NGO's exist that can offer technical assistance in production and processing.

6. Project replication

Within its program "Modernization, diversification and generation of rural employment", the Colombian Ministry of Agriculture prepared a "Plan for the modernization and strengthening of the cassava agroindustry in the Atlantic coast" (1995-1998) with a budget of Col$2500 million that contemplates a component focusing on market research and the expansion of the cassava flour agroindustry with a budget of Col$180 million.

In addition, a farmer cooperative together with the local government of San Vicente de Chucurí, in the Dept. of Santander in northeastern Colombia, is executing a project to establish an enterprise centered in the production and marketing of cassava flour. The group, which has visited CIAT and the Chinú plant, has already purchased the washing, chipping and milling equipment and received plans of the redesigned plant.

D. SPECIFIC OBJECTIVE III.

To understand the factors affecting cassava-flour quality and their relation to end-product quality.

1. Doctoral thesis

Alejandro Fernández, professor of food technology at Universidad del Valle and active participant in this project, initiated work in a doctoral thesis entitled "Study of varietal and processing influences on the physical-chemical and functional properties of cassava flour and starch", under the supervision of Dr. June Wenham from the NRI in England, beginning the second semester of 1993. Alejandro will finish his thesis at the end of 1995 and will return to UNIVALLE in Cali. His work forms part of the European Union-financed project on "Processing of cassava-based products" which involves collaboration among CIAT, Univalle, CIRAD-SAR and NRI.

The first part of this research was carried out at CIAT, consisting in the evaluation of CIAT's core collection of cassava germplasm and the selection of two cassava clones, CM 3306-4 and MVen 25, that exhibit variability regarding cyanide, dry matter and amylase content. Afterwards, samples were prepared taking into account the following variables: drying temperature (40, 60 and 80°C), milling option (hammer, roller, or fin mill), particle size (<250 µm and <160µm) to evaluate their influence on quality, functional properties and product potential.

E. SPECIFIC OBJECTIVE IV.

To promote the dissemination of information on available cassava-processing technology in other relevant countries of Latin America, Africa and Asia.

1. International cassava flour and starch meeting

CIAT and CIRAD organized this meeting that was held from 11-15 January 1994 at CIAT. This event was a fusion of the international cassava flour meeting financed by IDRC, and the first annual meeting of the project on development of new-cassava based products, financed by the European Union.

The event was divided in six sessions with 50 speakers and 40 posters. In total, there were more than 130 participants from 30 countries including lecturers and audience, most of them financed by IDRC, French Cooperation, European Union, CIRAD, CIAT, NRI and ORSTOM. Visits were programmed to the cassava flour pilot plant in the Atlantic coast and to the small-scale starch plants in the Dept. of Cauca.

The technical sessions included: Current and potential uses, physical and chemical studies of flours and starches, Bioconversions and use and treatment of by-products, Technology development, New products and Integrated projects.

2. Peru

CARITAS is an international Catholic charity related to the Catholic church with 44 office in Peru, including 7 in the Amazon region. Both CARITAS and the Instituto de Investigaciones para la Amazonía Peruana (IIAP) have taken an interest in the cassava flour production technology, and the former has installed four plants while IIAP has established two. Plants are operated by small farmer groups. The processing equipment was designed and manufactured in Cali with support form the Cassava Utilization section.

The flour is sold to industrial markets (vegetable adhesives, plywood) where it replaces imported wheat flour. Locally produced cassava flour can easily compete with other raw materials in locations such as Pucallpa, where transportation costs make imported goods expensive.

In 1994, two professionals of the Cassava Utilization section participated in a training program on the production of cassava flour and quality control. They also collaborated in the technical evaluation of an IIAP plant in Pucallpa.

3. Ecuador

In 1992, the second-order organization of cassava-processing cooperatives, UATAPPY, based in Manabí province, produced small quantities of high-quality flour for sale to small bakeries and a pasta manufacturer. The process used differs from that employed in Colombia, consisting of the natural drying of chips made from manually peeled roots. The microbial quality of this flour appears variable, and not critical for the small local clients currently purchasing this product. Market expansion may require quality improvement, however.

In 1994, a study was conducted by an NGO based in Quito, FUNDAGRO, to identify markets for cassava flour in the food and non-food industries of Ecuador. UATAPPY had obtained technical assistance in market research from the Cassava Utilization section in 1993.

F. SPECIFIC OBJECTIVE V.

To study the effect of free-market policies on wheat imports and prices across Latin America.

The Cassava Economics section prepared several documents analyzing the impact of the open market policy in the cassava sector of Colombia and the Cassava Utilization section monitored prices of wheat flour (Correa and Henry, 1992; CIAT, 1993, Henry, 1993).

Effect of open markets on wheat

Regarding wheat, the establishment of the open markets policy meant that the government, through IDEMA, lost its monopoly of wheat imports as the wheat mills remained free to conduct their own imports in 1993.

The 13% tax levy was also eliminated, by means of the Decree 3095 of 1990, for both wheat and wheat flour. Additionally, the tariff for wheat and wheat flour was changed form 20 and 50% respectively in 1991 to 15 and 20% in 1993.

The resulting increase in the internal supply of wheat and the tariff reduction caused a strong fall in prices of wheat flour. Prices of wheat flour in Col$ remained static from 1992 though 1994B (three years). The price of wheat flour increased 17% towards the end of 1994 and presented another 7% increase in 1995. This means that wheat flour has exhibited a 60-70% real-price decrease in the last three years.

Effect of open markets on cassava agroindustry

In general, a tariff reduction for the importation of production inputs in the open market context will not have a significant effect on cassava's cost of production because only 15% of production costs are derived from imported inputs. However, the relative prices of cassava will increase in comparison to other carbohydrate sources such as rice and potatoes. It is anticipated that consumers will make a certain degree of substitution, which will reduce the demand of cassava in the fresh market, especially in urban areas.

The import tariffs of the majority of products that compete with cassava-derived products have decreased significantly since 1993. The prices of cassava chips and of its substitutes in the animal feed market demonstrate that pellets from Thailand can be "dumped" in Medellín at a lower price that local chips.

Although Colombia has an "antidumping" law, it is difficult to implement and does not offer any real protection. Additionally, cheap animal feed from USA and Mexico are a real menace.

To remain competitive in the medium and long term, the cassava sector must minimize production and processing costs. However, scarce concerted efforts by national research and extension institutes is expected, because agricultural research is being privatized and extension is being decentralized. Furthermore, credit availability for small cassava producers is extremely poor compared to other crops.

In the short term, markets for cassava-based products require government protection that will enable it to consolidate and become more efficient and competitive. A serious limitation is the lack of a strong trade organization that can conduct lobbying with the government.

OTHER ACTIVITIES

Project meeting (1992)

A meeting was held in Sincelejo in August 1992 with the participation of CIAT and COOPROALGA to analyze project progress. Given the initial sales of cassava flour in the Atlantic coast, it was decided to initiate some of the activities related to project expansion.

Project meeting (1993)

A meeting took place on March 1993 at CIAT to present project activities during 1992 and to plan work for 1993. It was decided to proceed with selected activities related to the expansion phase.

FUNDIAGRO meeting (1993)

A meeting was organized in June 1993 in Sincelejo with the participation of members of FUNDIAGRO and COOPROALGA to establish the Operating committee of the cassava flour pilot plant and to analyze the state of progress.

Project meeting (1994)

A meeting was held in January 1994 to review CIAT and NRI activities in 1993, to study project feasibility in the context of open markets and to propose a workplan for 1994. Personnel from CIAT, IDRC, NRI and FUNDIAGRO attended.

Project meeting (1994)

A second meeting was conducted in October in Sincelejo. The first day was dedicated to internal project analysis and the annual presentation by FUNDIAGRO. The next day, the cassava flour project was presented to an audience including representatives of the cooperative, government and private enterprise sectors. The promotional video developed in this project was also presented.

PROJECT FEASIBILITY: CONCLUSIONS AND RECOMMENDATIONS

Under current conditions, it is considered that project feasibility is uncertain. The main constraints are related to the raw material: high root prices and deficient supply and quality of cassava roots. In addition, the executing farmer cooperative, COOPROALGA, exhibits insufficient entrepreneurial abilities. The following conclusions support this opinion.

- The chief achievement of this project has been the development and operation of an efficient process for production of cassava flour which includes a small-scale milling system.

- Currently, the plant has a secured market of 8-10 tons of cassava flour per month, or 60% of its capacity, located in the cities of Sincelejo, Valledupar and Barranquilla. This amount can be increased by eight tons in the near future in Barranquilla, where a potential demand of 40 tons for adhesives has been detected. There are other cities in the region which have not been explored in this sense, such as Cartagena, Valledupar and Montería.

- However, project expansion is still not justified by market demand. Although potential market demand in the region of 60 tons/month has been estimated, the realization of this demand depends on strong support in the areas of product development and marketing to strengthen position in current markets and penetrate new ones.

- Plant operation has not demonstrated that this is a profitable business. It is anticipated that if the following conditions are met, the plant can be a profitable enterprise: (i) the process is handled rationally, (ii) there is a continuous supply of quality roots, (iii) there is a market of at least 16 tons per month (80% of installed capacity), (iv) working capital is available when needed, and (v) production takes place only during the five-month period (December-April) when root supply is high.

- The plant has presented losses mainly due to (i) the lack of a sufficiently large and stable market, (ii) operation during periods of low root supply, and (iii) low dry matter content of roots in Chinú (ICA-P12).

- Although cassava root supply and price conditions are unfavorable in 1995 for rural agroindustry, this situation can be normalized in the near future with the provision of adequate credit to small farmers.

- A current priority is to support the cooperative in obtaining improved varieties destined for agroindustry and exhibiting a high dry matter content.

- Another priority is to design a raw material supply program. To guarantee an adequate supply of raw material, the producer must be backed with credit, technical assistance, access to land and healthy seed. The producer must diversify and plan the production, using varieties both for the fresh market as well as for agroindustry and by planting the hectares required by the market.

- Continuous and participative in-service training has enabled COOPROALGA to perform the activities related to processing and plant management. However, they lack enough entrepreneurial skills for obtaining raw material, credit and marketing the cassava flour product.

Suggestions for future interventions

Several suggestions regarding rural agroindustry projects involving product development, such as this one, should be made.

The first one is that the integrated project concept is very similar to the business or entrepreneurial focus to rural development. Both recognize, as a starting point, the identification of market opportunities and the importance of an integrated and multidisciplinary intervention involving production, processing, marketing and product development, together with an adequate institutional support including credit and technical assistance. As we have already discussed, intervention in the area of production to guarantee the supply of low-priced, quality raw material is critical.

The second point to underline is the importance of Research and Product development (R&D) and its strong interdependence with marketing. R&D can be defined as the process by which a product is designed to meet market requirements. In addition to defining appropriate physical and chemical product characteristics, it can involve brand names, packaging and advertising. This process can be lengthy and should be started some time before the commercial stage is initiated. The reason for this is that the marketer of the new product has to be aware of client needs and the new product should reflect this knowledge.

Thirdly, the entrepreneurial issue is critical. It is vital to seek this ability when searching for potential executors of agroindustrial projects. This virtue is not common, least in rural areas. But one must find it, maybe among rural intermediaries, or among owners of existing rural microenterprises. In any case, it is important to avoid the unrealistic perspective that assumes that it easy to convert simple farmers into wise entrepreneurs in a relatively short period of time.

REFERENCES

Alonso, L. 1995. Manual de operación para una planta de harina de yuca. Draft version. Cassava Utilization Section, CIAT. Cali.

CIAT. 1988. The production and use of cassava flour for human consumption. Final report: Research phase. Cassava Utilization Section. Cali. 85 p.

CIAT. 1992. Producción y comercialización de harina de yuca para consumo humano. Informe final: Fase de Proyecto Piloto. Cassava Utilization Section. Cali. 290 p.

CIAT. 1992. Production and marketing of cassava flour in Colombia. Annual report 1992: Expansion phase. Cassava Utilization Section. Cali. 40 p.

CIAT. 1993. Cassava flour. In: Cassava Program Annual Report, p. 227-233. Working document. Cali.

CIAT. 1994. Cassava flour. In: Cassava Program Annual Report Working document (to be published). Cali.

CIAT. 1993. Situación actual y perspectivas del cultivo de yuca en Colombia. Informe preparado para el Gobierno colombiano por la Sección de Economía de Yuca. Cali. 15 p.

CIAT. 1994. Producción y mercadeo de harina de yuca en Colombia. Informe anual 1993: Fase de expansión. Cassava Utilization Section. Cali. 41 p.

Correa, C. and Henry, G. 1992. Desarrollo de la yuca en América Latina en las décadas 70 y 80 y perspectivas para los 90 ante la Apertura: el caso de la Apertura colombiana, Cuadernos de Agroindustria Rural, Celater. Cassava Economics Section, CIAT. Cali.

FUNDIAGRO. 1993. Acta No. 001: Primera reunión del comité operativo del proyecto piloto de harina de yuca. Working document. Sincelejo.

FUNDIAGRO. 1993. Informe sobre mercadeo de harina de yuca. Working document. Barranquilla. 7 p.

FUNDIAGRO. 1994. Producción y comercialización del proyecto de harina de yuca en Colombia. Informe de ejecución técnica (Julio 1993-Junio 1994). Barranquilla. 18 p.

Henry, G. 1993. Implications for the Colombian cassava sector as a result from "Apertura" government interventions. Working document. Cassava Economics Section, CIAT. Cali.

Jones, D. 1995. Field testing and implementation of improved cassava flour production process technologies. Final report. Cassava Utilization Section. NRI and CIAT. Cali.

Ostertag, C. 1995. Manual de administración para una planta de harina de yuca. Cassava Utilization Section, CIAT. Cali.

Ostertag, C. 1993. Plan de mercadeo para harina de yuca (Julio 1993 a Junio 1994). Working document. Cassava Utilization Section, CIAT. Cali.

Ostertag, C. and Wheatley, C. In press. A financial model for the implementation and evaluation of a small-scale agroenterprise. In: Scott, G. (ed.). Methods for agricultural marketing research in developing countries. CIP. Lima, Peru.

Padilla, A. and Velandia, H. 1993. Evaluación comparativa del comportamiento de la harina de yuca y la harina de trigo como estabilizante en un producto cárnico emulsificado. Trabajo de grado, Facultad de Medicina Veterinaria y Zootecnia, Universidad Nacional, Santa Fe de Bogotá. 91 p.

Viera, M. A. 1993. Informe sobre el desarrollo de adhesivos a base de harina de yuca. Working document, FUNDIAGRO. Cali. 8 p.

Viera, M. A. 1994. Proyecto de producción y comercialización de harina de yuca. Informe de operación de la planta en el primer semestre de 1994. FUNDIAGRO. Sincelejo. 35 p.

Viera, M. A. 1995. Proyecto de producción y comercialización de harina de yuca en Colombia. Informe sobre la operación de la planta en el segundo semestre de 1994. FUNDIAGRO. Sincelejo. 30 p.

Wheatley, C., Scott, G., Best, R. and Wiersema, S. Adding value to root and tuber crops: a manual on product development. Draft version. CIAT. Cali. 264 p.

ACRONYMS

CIAT	Centro Internacional de Agricultura Tropical (Colombia)
CIRAD	Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement (France)
COOPROALGA	Cooperativa de Productores de Los Algarrobos (Colombia)
CPC	Corn Products Company (International)
DRI	Fondo de Desarrollo Rural Integrado (Colombia)
FUNDAGRO	Fundación para el Desarrollo Agropecuario (Ecuador)
FUNDIAGRO	Fundación para la Investigación y el Desarrollo de Tecnologías Apropiadas al Agro (Colombia)
IDEMA	Instituto de Mercadeo Agropecuario (Colombia)
IDRC	International Development Research Centre (Canada)
IIAP	Instituto de Investigaciones para la Amazonía Peruana (Peru)
IIT	Instituto de Investigaciones Tecnológicas (IIT)
NRI	Natural Resources Institute (United Kingdom)
ODA	Overseas Development Administration (United Kingdom)
ORSTOM	Office de la Recherche Scientifique et Technique d'Outre-Mer (France)
SENA	Servicio Nacional de Aprendizaje
UATAPPY	Unión de Asociaciones de Trabajadores Agrícolas, Productores y Procesadores de Yuca (Ecuador)
UNIVALLE	Universidad del Valle (Colombia)

ANNEX 1.

ANALISIS DE RENTABILIDAD FINANCIERA
PROYECTO DE HARINA DE YUCA EN LA COSTA ATLANTICA DE COLOMBIA

PROCESOS: SECADOS NATURAL (HY-100M) Y ARTIFICIAL (HY-60M)
PRODUCTOS FINALES: HARINAS DE YUCA DE 60 Y 100 MESH, RIPIO Y TROZOS
FECHA: MAYO 1995

A. INVERSION ESTIMADA Y COSTO DE MANTENIMIENTO (COL$)

CONSTRUCCION (i)		COEFICIENTE DE MANTENIMIENTO	COSTO DE MANTENIMIENTO
ESTUDIO DE SUELOS	200000		
TOPOGRAFIA	200000		
CONSTRUCCION (nueva planta)	28000000	0.001	28000
TRANSPORTE EQUIPOS	1000000		
MONTAJE EQUIPOS	500000		
SUPERVISION	800000		
ADMINIST. Y CONTINGENCIAS (15%	4200000		
SUBTOTAL	34900000		

EQUIPOS Y SUMINISTROS

BASCULA (500 KG)	200000	0.001	200
MESAS DE SELECCION (2)	300000	0.001	300
ELECTROBOMBA DE AGUA	200000	0.001	200
LAVADORA	1000000	0.005	5000
TROZADORA	420000	0.005	2100
TOLVA	55000	0.001	55
MOTOR TROZADORA	200000	0.001	200
ARRANCADOR DE MOTOR	145000	0.001	145
VENTILADOR	700000	0.001	700
MOTOR DE VENTILADOR	430000	0.001	430
ARRANCADOR DE MOTOR	140000	0.001	140
QUEMADORES CARBON (2) Y DUCTOS	3000000	0.100	300000
CAMARAS DE SECADO	800000	0.001	800
CUBIERTAS DE SECADOR	50000		
PALAS METALICAS (6)	23000	0.001	23
ESTIBAS MADERA (6)	100000	0.001	100
CARRITO	150000	0.001	150
EMBUDOS (2)	120000	0.001	120
TRANSFORMADOR 50 KVA (INCL. PROTECCION, PERMISO, Y SUBESTACION)	4000000	0.001	4000
EMPAQUES POLIPROP. (300)	90000	1.000	90000
PREMOLEDORA	1500000	0.005	7500
MOTOR PARA PREMOLEDORA	200000	0.001	200
ARRANCADOR DE MOTOR	100000	0.001	100
SISTEMA DE MOLIENDA	1500000	0.001	1500
COSEDORA EMPAQUE	700000	0.001	700
MUEBLES	500000	0.001	500
SUMINISTROS	200000		
IMPREVISTOS (5%)	831150		
SUBTOTAL	17654150		
TOTAL	52554150	TOTAL	443163
DOLARES 880	59721		

D. MATRIZ DE FLUJO DE CAJA

	1995	1996	1997	1998	1999	2000	2001	2002	2003
TASA DE INFLACION		0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
FACTOR INFLACIONARIO			1.250	1.563	1.953	2.441	3.052	3.815	4.768
INVERSION INICIAL	52554150								
INGRESOS:									
VENTAS		55100085	68875106	86093883	107617353	134521691	168152114	210190143	262737679
VALOR RESIDUAL (vii)									100239086
MENOS:									
COSTOS VARIABLES		46840820	58551025	73188781	91485977	114357471	142946838	178683548	223354435
COSTOS FIJOS		3023163	3778954	4723692	5904615	7380769	9225961	11532452	14415565
TOTAL COSTO PRODUCCION		49863983	62329979	77912473	97390592	121738240	152172800	190216000	237770000
COSTO CAPITAL TRABAJO		4986398							
FLUJO DE CAJA NETO	-52554150	249704	6545127	8181409	10226761	12783452	15979315	19974143	125206765
PRECIO PUNTO DE EQULILIBRIO		342815	389562	486953	608691	760864	951080	1188850	1486062
TON PUNTO DE EQUILIBRIO		155	59	59	59	59	59	59	59
TASA DE PRODUCCION REAL		0.97	0.37	0.37	0.37	0.37	0.37	0.37	0.37

E. CALCULO DE PARAMETROS DE RENTABILIDAD

TASA FINANCIERA DE RETORNO (TFR): 22%

TFR MINIMA ACEPTABLE O COSTO
DE OPORTUNIDAD DEL CAPITAL 30%

VALOR PRESENTE NETO USANDO
UNA TASA DE DESCUENTO DEL 30% -12229934

NOTAS:

(i) SE ASUME QUE LA TIERRA ES DONADA POR LA COOPERATIVA
(ii) LA PRODUCCION ANUAL ES HY-60M PARA LUEGO EXTRAER LA HY-100M.
(iii) LA EXTRACCION DE HY-100M ES 90 %, DE HY-60M ES 82 % Y PERDIDAS DE 1 %.
(iv) SE BASA EN YUCA DE BUENA CALIDAD SIN SELECCIONAR NI ADECUAR. EL RECHAZO (20 %) SE PROCESA EN TROZOS SECOS PARA CONSUMO ANIMAL.
(v) SUMA PAGADA DURANTE EL PERIODO DE OPERACION.
(vi) PRECIO PONDERADO DE PRECIOS DE HARINAS DE 60 Y 100 MESH, RIPIO Y TROZOS.
(vii) SE SUPONE IGUAL AL 40 % DE LA INVERSION INICIAL SIN VALORIZAR EL TERRENO.