CIAT'S EXPERIENCES IN THE PROMOTION OF SMALL-SCALE CASSAVA-BASED AGROINDUSTRIES IN LATIN AMERICA

BERNARDO OSPINA AND RUPERT BEST[1]

INTRODUCTION

Cassava cultivation and processing activities provide household food security, income and employment for over 500 million people in Africa, Asia and the Americas. Cassava is mainly produced by small farmers in highly diverse and complex farming systems with little use of modern technological inputs. The crop plays an increasingly important role in ensuring food security, especially in marginal agroecologies where there are few other cropping alternatives. Its high yielding ability under marginal conditions, adaptation to drought, tolerance to pest and disease attack and indeterminate harvest period contributes to sustaining production on limited land areas, reducing seasonality of supplies, minimizing risks of crop failure and moderating labor constraints. All of these factors are closely related to food security at the household level and make cassava a subsistence crop *par excellence*. However, as urbanization continues to be a dominant demographic force and rural populations continue to migrate to urban centers, major changes in diet and food consumption patterns are occurring. As urban markets have developed and cassava farmers have moved into the market economy, they have been confronted by a diminishing demand for their traditional product. The challenge for agricultural researchers and policy makers lie in promoting the transition of cassava from a basic staple that provides a substantial element of food security to rural economies, into a multi-use carbohydrate source, as a means of maintaining the income generating potential of the crop. In this process, it is necessary to link the small-scale farmer to alternative and expansive markets. This paper presents the experiences of the Centro International de Agricultura Tropical, in supporting and collaborating with international and national agricultural research, technology transfer and development institutions to achieve these goals.

METHODOLOGY

CIAT's Cassava Program goal is to enhance the crop's contribution to the well-being of cassava farmers, processors and consumers. To achieve this goal, knowledge, research methods and technology components are generated whose deployment will lead to sustainable improvement in the level, quality and stability of cassava production, diversification in the end uses of the crop and increased food security..

The Cassava Program uses an interdisciplinary, commodity system approach which seeks to integrate research in germplasm improvement with research in crop management and process, product and market development. Early in its history, the program recognized that research in product, process and market development was the key to maximizing the crop's true potential as a source of additional income for small- to medium-scale farmers.

Experiences obtained by CIAT and counterpart institutions during the last 15 years have resulted in the development of a generalized methodology for linking cassava farmers to potential growth markets via new processing technology and new product development. This methodology aims at coordinating changes in farming systems with changes in the marketing system within the framework of a multinstitutional integrated project. This methodology is known as **Integrated Cassava Research and Development Projects (ICRDPs)**.

The ICRDPs are defined as an institutional, technological, social and organizational intervention designed to link small-scale cassava farmers to new or improved growth markets thus stimulating demand for improved production technology components. The ICRDP methodology consists of four sequenced stages (Fig. 1) described as follows:

[1] The authors are Senior Research Fellow -Cassava Program and Interim Deputy Director General-Research, Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia, respectively

Macroplanning: This stage analyzes the overall socio-economic and rural development situation of a country or region targeted for the ICRDP. These studies help in the identification of potential demand for cassava and derived products, the ability of the crop to compete with other products, as well as the potential for cassava production in different regions. The most promising market and the correct target region are selected in this stage.

Microplanning: Within the target region, information is generated to define market characteristics, production practices and constraints, availability of institutional support, existing farmers' organizations, cassava processing technologies and government priorities. The end result is the selection of the site for implementation of the pilot project and the identification of institutional partners..

Pilot project: The pilot project is used to evaluate the technical, economic and operational feasibility of production and post-harvest technology under local, real conditions. Farmers are important project actors and decision-makers during this stage. Experiences are gained in aspects of farmer organization and training which may be employed during the expansion stage to follow. At the end of this stage, sufficient first-hand data is available to be able to formulate or reject an expansion to commercial scale operation..

Commercial expansion phase: Replication of the use of the cassava production and processing technology and the new or improved product is promoted in this stage. Credit lines for crop production and processing and institutional requirements for training and technical assistance for farmers can be formulated based on real costs. A monitoring system is established based on information gathering mechanisms initiated during the pilot stage. The monitoring system is important in helping to determinate how the benefits of the introduced technology are being distributed, and providing feedback for the resolution of constraints that are encountered during commercial operation..

Complementary to the ICRDP strategy, CIAT's Cassava Program has been actively involved in generating and transferring production and post-harvest technologies. Cassava post-harvest research and development is based on a market-oriented, product development approach in which unsatisfied consumer needs are identified and processes are developed to fulfill these needs. This "product development strategy" together with the process of generating improved production technology is a key part of the broader strategy of integrated cassava projects. The process of product development is divided into four distinct stages (Fig.1), described as follows (Wheatley et al., 1995):

Identification of product ideas. A large number of ideas is first generated and then the best options are selected for further investigation based on market and technological factors.

Research: During this stage, market studies and consumer research are carried out to identify demand and the required characteristics of the selected products. Simultaneously, technical research focuses on the product and the processes needed for its production. With the information generated in this phase, a prefeasibility study can be prepared.

Pilot and commercial phase: Following a positive prefeasibility study, a pilot stage is initiated to introduce on a reduced scale, into a specific cassava growing region, the post-harvest and the associated production technologies. In this phase the technology is operated by the intended beneficiaries. The pilot phase involves risks because the process and products are still unproven. Since farmers are investing time and resources, this phase and the subsequent commercial phase are better carried out within the context of an ICRDP or rural development project that can provide the desired level of institutional, financial and logistical support (Fig 1).

CIAT and collaborating institutions have been implementing activities in which the ICRDP and product development approaches have been integrated with the aim of linking cassava farmers to expanding markets. To review the results, lessons and implications of this work, the analysis will concentrate now on research and development work carried out with four processing technologies that have shown to have the greatest potential for promoting and absorbing increased cassava production. These products are: dry cassava for animal feed, fresh cassava for human consumption, cassava flour as a human food, and cassava starch for the food industry.

1. DRY CASSAVA FOR ANIMAL FEED

Up until 1980, research work at CIAT on dry cassava was aimed at developing the natural drying technology employed in Asia with a view to improve the quality of the dry product . This work carried out in collaboration with the Tropical Products Institute- TPI[2] allowed CIAT to gain considerable experience and know-how on cassava drying especially natural drying technique such us those used in Thailand. In 1980 the Colombian government requested CIAT's assistance in resolving the problem of excess cassava production and lack of markets in the Atlantic Coast region of the country. At the same time, the Cassava Program was confronted with doubts about its ability to reach farmers with the technologies generated and to attain increased productivity. After a series of internal planning exercises focusing on social objectives , a new research and development framework was formulated including the need to be directly involved in cassava-based rural development programs. The Program therefore joined forces with the Colombian government and a pilot project was initiated to assess the technical and economic feasibility of producing dry cassava chips for the animal feed industry. The dried chip market was considered promising because of the rapid development of the national poultry and swine industries. The pilot project was started with a small farmers'association and since then has grown to be a regional project with over 100 farmers'groups and an annual output of 35,000 t per year.

Acceptance by the feed manufacturers of dry cassava as a raw material in their rations was key to the success of this post-harvest technology. The cassava crop has several advantages compared with other carbohydrate sources, especially other root crops. Root dry matter content is higher, at 35-40%., giving optimum conversion rates of 2.5:1 or better. Over 85% of root dry matter consists of highly digestible starch. 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; when moisture content falls below 14% a stable product is obtained. Drying also permits the elimination of most of the cyanide present in root tissues. The disadvantage of low protein content can be overcome through price competitiveness.

The experiences obtained by CIAT in Colombia resulted in the formulation of a generalized methodology for integrated cassava research and development projects. The drying technology has spread from Colombia to Ecuador and Brazil, where it has been adopted with great success. It is estimated that about 350 drying plants now operate in Latin America. The underlying philosophy behind the ICRDP's was that declining traditional cassava markets did not offer incentives for cassava farmers to adopt technologies for increasing production. The introduction of an alternative market should increase demand and encourage technology adoption by farmers. Data obtained from surveys conducted in Colombia, Ecuador and Brazil to analyze adoption patterns for production and processing technologies and the economic impact brought about through their adoption is summarized as follows:

- **Evolution of the dry cassava industry**. In 1994 there were more than 150 farmer's cooperatives and associations and private entrepreneurs operating in the Atlantic Coast with an annual production of dry cassava estimated in 35,000 t per year and a total value of near US$ 6,2 millions. This represents a demand for 90,000 t of fresh cassava roots and corresponds to approximately 10% of the total cassava commercialized in the region (Henry et all, 1994).

  In Ecuador the growth of the project was not in the number of farmer's cassava processing organizations but rather in the capacity of each processing unit. In 1992 there were 17 associations in the province of Manabi with a total of 320 farmers. The market initially developed in Ecuador for dry cassava chips was for the Ecuadorian shrimp industry. This industrial market was based on the discovery that cassava flour can substitute for imported chemical agglutinants for fish feed pellets. In 1989, this market represented a demand of over 8,000 tonnes /year. When this market collapsed, other important industrial uses were rapidly identified. A very important experience related to market diversification was developed with strong farmer throughout the process.

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[2] Now the Natural Resources Institute, NRI

In the State of Ceara, Northeast Brazil, the dry cassava processing technology was adopted rapidly. In three years from 1989, the number of cassava-based agroindustries increased from 8 to 158. This exponential growth was possible through local agencies successfully approaching different government agencies and programmes on behalf of the farmers' groups to obtain grants. Diverse programs of grant-type financial aid were then launched and farmers were helped to build their cassava processing agroindustries.

- **Evolution of cassava roots prices at farm level** . Cassava root prices paid by the processing plants in Colombia, are usually lower than those paid by the fresh market but annual fluctuations in prices have diminished. The introduction of an alternative market for the fresh product has also acted as price regulator in the fresh urban market with has benefited urban consumers.

In Ecuador, total cassava production and cassava prices at farm-level have increased during the last years in the Province of Manabi. As a consequence, small farm households have benefited from the introduction of the alternative markets.

In Brazil, severe variations in supply and prices of *"farinha de mandioca"* (a roasted cassava flour) have diminished when the cassava-based rural development project was implemented and as a result, an alternative commercialization system was developed in which farmers are being paid better prices for their cassava crop.

Evolution of area planted. In the Colombian and Ecuadorian cases, increased demand and price stabilization has reduced commercialization risks for cassava roots and created an incentive for expansion of planted area. According to data from the Ministry of Agriculture, Colombia, during the period 1980-84 total area planted with cassava in the region diminished at an annual rate of 7.5%. This situation was reversed from 1985 up to 1991. a period in which the area planted with cassava increased at an annual rate of 11.4% . 50% of farmers mentioned improved market and existence of cassava drying plants as the principal reasons for increasing cassava areas (Gottrett et al., 1993). In Brazil, the span of the project coincided with two consecutive years of severe drought and seasonal availability of surplus roots for processing into dry cassava was affected .

Adoption of improved production technologies. Increased cassava production in these regions was due not only to increased area but also to increased productivity as a result of adoption of improved production technologies. In Colombia, studies indicated that adoption levels were significantly higher for areas with improved market access and institutional support compared to those areas with only the traditional fresh market. This has been shown for different types of technology components i.e. varietal, management and practices that demand additional inputs. The adoption of cassava production components since 1984 has resulted in considerable yield gains of 12-25% with respect to traditional market areas (Henry et al., 1994). Both yield gain and adoption levels were significantly higher in areas were cassava technology components were integrated (Table 1). In Ecuador, farmers' adoption of an improved cassava variety, in whose development they participated, resulted in increased yield and better quality of the roots for the processing operations. However. in Brazil the project's impact on cassava productivity and adoption of improved production technology has been impeded by lack of opportunities for farmers to purchase or rent additional land or purchase inputs.

- **Distribution of benefits.** Estimates made by CIAT calculated that during the period 1984-1991, the cassava sector in Northern Colombia benefited by almost US$ 22 million when research to improve cassava crop management was integrated with research on processing, marketing and consumer preferences (Gottret et al.. 1993). Cassava producers were the group that most benefited from the integrated cassava project in the region gaining 69% of the total benefits. Feed manufactures captured 20%, urban consumers 9% and farmer processors received 5.%. The only group that presented losses as a consequence of the new market were the intermediaries to whom stabilization of prices for fresh cassava represented a loss of 3.% of the total benefits (Table 2).

In Ecuador. annual average income earned by farmers members of the cassava-based agroindustries was US$ 225 over a six-year period whereas non-members gained only US$ 85. Additionally, important income was captured by groups such us women non-members, landless farmers and children when peeling the cassava roots was needed to attend the requirements of the new markets. These activities were, in many cases, the only source of off-farm income for these groups.

In Brazil, total income gained by farmers during the three years of the project reached US$ 163,689 of which nearly 40% corresponded to sales of cassava roots, 10% to processing wages and about 50% corresponded to profits in the commercialization of the dry cassava. These benefits were distributed among smallholders (60%), renters (32%) and sharecroppers (8%) (Ospina et al., 199).

2. FRESH CASSAVA FOR HUMAN CONSUMPTION

The highly perishable nature of fresh cassava roots make it a risky product to market and an inconvenient and expensive food of variable quality for the urban housewife. If this problem could be resolved, a good quality, inexpensive and convenient source of carbohydrates could be made available to the urban population. One possible solution is to breed cassava cultivars which are less susceptible to physiological deterioration, but research has shown that resistance is highly correlated with low root dry matter content and/or poor eating quality. A genetic solution to this problem appears then difficult although with modern biotechnology approaches, a solution may eventually be possible through genetic manipulation.

In the short term, post-harvest research offers the only solution. Work carried out by CIAT in the 70s with the TPI, London, served to develop two simple storage techniques: field clamps for on-farm storage and packing in boxes with moist sawdust for transport and use in urban settings. Later, these two methods proved not to be suitable for the conservation of large volumes of fresh cassava because of the high costs involved. Market research showed that a storage time of two weeks was sufficient to allow for a one week farm to retail outlet period, with an additional week of at-home storage. Post-harvest technology research at CIAT and NRI, UK, resulted in the development of a simple storage technology based on packing roots on polyethylene bags to encourage wound healing reactions, which effectively prevent atmospheric oxygen from penetrating the root tissues and triggering the oxidative reactions of physiological deterioration. A chemical treatment of roots with a thiabendazole based fungicide, is sufficient to control secondary, microbial rotting which can develop on the surface of the roots due to the humid microclimate of the bag during storage. Thiabendazole is a chemical widely approved for the post-harvest use of perishable foods. The thick peel of cassava roots is discarded during food preparation and actual measured residue levels are less than 1 ppm (5 ppm are accepted for potatoes). The combination of polyethylene bags plus chemical treatment provides for a shelf life of two to three weeks (Best et al., 1990).

In the late 1980s, pilot projects were deployed in Colombia to test this technology with farmers and consumers. These pilot project included market studies to identify commercialization channels as well as consumer evaluation trials to ensure the acceptability of the new product. A consumer panel reported that eating quality of cassava roots stored for two weeks not only compared favourably with fresh cassava but also the advantages of convenience and quality were real and should result in consumption increases (Table 3). A collaborative project between CIAT and the Ministry of Agriculture promoted the expansion of the pilot project in the city of Barranquilla. Cooperatives of small farmers supplied fresh cassava to a distribution enterprise run by a federation of small farmer cooperatives (second order organization). Bagged cassava had considerable success in supermarkets and in small local shops, where retailers report increases in volumes sold. However, problems arose regarding the organization of the expansion of the cassava supply and distribution networks. These problems were mainly associated with lack of working capital and the absence of a product promotion campaign on a massive scale. This latter point is very important. Changing the urban image of fresh cassava as a product of low quality and convenience into an accepted urban food requires that urban consumers are made aware of the advantages of purchasing bagged cassava. This requires considerably management and entreprenurial skills, together with adequate financial resources. Unfortunately these resources were not available to permit expansion of the project in Colombia.

The polyethylene bag storage technology was introduced at a pilot level into the cassava-based development projects in the province of Manabi,Ecuador and for a period bagged cassava was exported to the U.S.A. Noncontinuity of supply caused this product option to be abandoned. By 1990, in Paraguay the introduced technology had progressed to a semi-commercial stage (10 ton/month) with excellent product acceptability by retailers and consumers. One farmers' organization has expanded its operation to commercial scale

3. CASSAVA FLOUR FOR HUMAN CONSUMPTION

In Latin America cassava flour has only been successfully produced and used in Brazil. During the 1960s and early 1970s , in Brazil, a law required the use of a small percentage of cassava flour in wheat flour based products and cassava flour was widely used as a partial substitute for wheat flour in breadmaking In the mid-seventies, heavy wheat flour subsidies were introduced and the relative price of cassava flour to wheat flour favoured wheat flour. This has the effect of destroying the cassava flour industry that had been built around São Paulo. Others countries as diverse as Panama, Guyana, Jamaica and Colombia have also made attempts at establishing cassava flour industries.

Three reasons stand out as being common denominators in all these country experiences: the existence of wheat subsidies that makes difficult for cassava flour, the selection of an inappropriate scale of processing technology and an inadequate effort to promote cassava cultivation among local farmers. With these points on the research agenda, CIAT initiated in 1984, with several national institutions a project to research the feasibility of establishing a rural based cassava flour industry under Colombian conditions. In 1995, upon finishing an expansion phase of four years (1992-1995), the following results have been obtained (CIAT Cassava Program, 1995):

- **Profitable operation of the pilot processing plant** . An efficient processing system was obtained that resulted in lower production costs. Drying time and costs were reduced and this resulted in improved overall microbiological quality. A small-scale milling system for dry cassava chips was developed which allowed commercialization of cassava flour in local markets. Overall profitability was relatively low and external factors such us high cost and low quality of raw material and low prices of products competing with cassava flour were identified as the main constraints.

- **Market development** - Market studies have identified various uses of wheat flour that can be met with cassava flour . Cassava flour could be used by almost any commercial enterprise producing flour-containing products. In both processed meats and biscuits /cookies, the use of cassava flour has resulted in a significant improvement in product quality over wheat flour . For example, cassava flour has better properties of water absorption than wheat flour and thus produces a sausage with a better body, color and flavor than one containing wheat flour. Consumer panel tests conducted by the food industry have confirmed this findings (Table 4). In general, cassava flour was as acceptable as wheat flout to industry after minor modification as in process or product formulations. If available in the market at a price 10 percent below that of wheat flour, cassava flour will have a market of at least 30.000 tons/year in Colombia alone, considering only those products for which the cassava flour has a clear advantage over wheat flour.

Expansion of the cassava flour agroindustry . Project replication and expansion is being promoted by the Colombian government in the Atlantic coast region with a budget of US$ 2 million. A farmer cooperative in another region of Colombia is also executing a cassava flour project. In the Amazon region of Peru, a project is promoting the establishment of six cassava flour agroindustry. In Ecuador, small cassava producer-processors organized into a 2nd order farmer organization or Union -UATAPPY, have been developing milling capacity and management to produce cassava flour from grinding dry cassava chips. In 1992 the Union was producing seven different primary products and 4 byproducts and selling them into several different market sectors.

The technical feasibility of this post-harvest technology has been achieved and an efficient process for production of cassava flour which includes a small-scale milling system is available. Under current conditions in Colombia, economic feasibility us uncertain due mainly to high root prices and deficient supply and quality of cassava roots. Additionally, lack of entrepreneurial skills and abilities by the farmer group in charge of the project has shown to be another important constraint. Currently, the pilot plant has a secured market corresponding to 60% of its installed capacity and project expansion is still not justified by market demand.. Establishment of open market policies in most Latin American countries is another factor affecting economic feasibility of cassava-based processing enterprises considering that import tariffs for the majority of products that compete with cassava-derived products have decreased significantly since 1993. To remain competitive in the medium and long term, the cassava producers must minimize production and processing costs that facilitate producing cassava-based products at competitive prices. Additionally, they will need to develop greater technical and entrepreneurial skills and enough lobbying power to be able to defend their sector at the policy decision level.

4. CASSAVA STARCH FOR THE FOOD INDUSTRY

Sour cassava starch, a naturally fermented cassava product, is an important agroindustrial activity in some regions of Colombia, especially in the Department of Cauca. Despite its great importance and potential for broader industrial applicability including partial replacement of wheat flour in food products, this agroindustrial sector presents various limitations related to the technological level and the quality of the final product. Fermented (sour) cassava starch produced in this region for local cheese breads is the main commercialization outlet although significant quantities of sweet starch are also produced for use in industrial processes (paper, textiles, foods). Quality demands and standards for these industries are more strict than for sour starch and this product has strong competition with other sources of imported starches. To address these issues, CIAT initiated in 1988 in collaboration with CIRAD-SAR, France, research and market development activities with starch that have led to the following results (Dufour, 1995):

- **Process improvement**. In Colombia, traditional processing units are known as *rallanderias (rallar* means "to grate" in Spanish), and basically consists of three machines: a root washer/dehuller, a grater/rasper, and 1-2 sieves for the wet extraction of starch . Almost all of the plant have only one electric motor, which powers all of the machines by means of a system of pulleys and driving belts. This enables an important reduction in installation costs and allows rapid switching to a petrol-driven motor in the event of an electricity cut, thus avoiding deterioration of already-harvested cassava roots. In general, these rallanderias present a poor plant distribution due to the forced proximity of the machines. 5 tonnes of cassava roots are handled in one day and the operator has to transport this volume three times from one machine to another.

  To improve the efficiency of the process and the quality of the product, an improved pilot plant was developed and installed in the Department of Cauca, similar in scale to 200 other farmer-operated production units in the region. Operation of the pilot plant has enabled multidisciplinary research and training activities for researchers, university professors, students, local equipment manufacturers and small scale cassava producers and processors. One of the initial conclusions of this project is that locally-built equipment, with processing capacity of up to 5 tonnes of roots per day, is highly efficient, simple and economical and that its replacement with other equipment is not needed. Efforts were then concentrated towards improving the design of the plant and some operational details. One important modification was the distribution of the machines in such a way that maximum benefit is taken from the slope of the terrain, making use of gravity to transport material through the process. This arrangement eliminates the need for operators to manually transport the material from one machine to another. Additionally, each machine has its own motor and protective features (Fig. 2). Sedimentation channels have been added to the plant to facilitate collection of sedimented starch, provide continuous operation of the processing plant and improve the quality of the product.

- **Research for market development and environmental control.** Fermented starch has proven to be unique in terms of conferring expansion properties to bakery products. Trials with maize, rice and potato failed to produce modified starches with expansion properties. This cassava characteristic could open important niche markets for starch in dietary and gluten-free products. A hydrocyclone that concentrates starch milk and thereby reduces water use has been successfully field tested by NRI in small-scale starch extraction in Colombia. The adoption of this simple technology would substantially reduce the polluting effect of effluents from these factories.

- **Technology transfer for the production of cassava sour starch.** In collaboration with UATAPPY, in Manabi, Ecuador, technology transfer activities have been conducted aimed at improving process and quality in various starch production plants belonging to UATAPPY. In Ecuador, small-scale extraction of starch has existed for over 100 years with little change in the processing technology. Peeling and sieving operations are performed manually and now the first washing and peeling machines are gradually appearing at the processing plants. The manual sieving operation enables a saving in water consumed of around 40% in comparison with the mechanized process. Currently in Ecuador, the production of 1 kg of dried starch requires 50 liter of water. The installation of sedimentation canals has also been adopted by Ecuadorian cassava starch producers.

5. LESSONS LEARNT

The Cassava Research and Development Projects (ICRDPs) and the activities on product and market development that are now under execution in several countries of Latin America have allowed CIAT to develop a dynamic framework for interaction with national and international research and development institutions as well as with farmer groups. This interaction has facilitated the validation and adaptation of existing production and post-harvest technology together with market analysis. It is hoped that these methodologies will be adaptable to different economic conditions, farming systems, markets and institutional settings. Based on this experiences, some factors have been identified as critical for successful implementation of these projects:

- **Interinstitutional Organization.** These projects involve from its very inception expertise in different areas and activities, usually beyond the scope of any single institution. Inter-institutional coordination mechanisms developed are usually new to the institutional setting and demand an adjustment period. Three components are basic for inter-institutional organization: (a) identification of a coordinating institution, (b) agreement on the necessary functions of each participating institution and (c) deployment of coordinating mechanisms at project, regional and national levels.

In relation to farmer groups, the promotion of their organization through cassava-based research and development projects has shown to be an attractive proposal that stimulates their participation. However, these organizations have shown to be exceptionally weak in the areas of business management and administration. The formation of second order farmer organizations that can support their members with a wide range of services and represent them in dialogs with institutions, government policy makers (lobbying power) and small- or medium-scale entrepreneurially run agroindustries has proven essential in the ICRDPs and product development experiences.

- **Human resource development.** Human resource development is a well-identified constraint that affects implementation of any rural development program. In the establishment of several ICRDPs in Latin America, the deficiency of persons and institutions specialized in post-harvest research, development and market has been highlighted. A great demand therefore exists for training opportunities for research and extension personnel and farmers in areas such us cassava processing, crop management, basic accounting, human & financial resource management, monitoring and evaluation, marketing analysis, etc. Training strategies for technicians should try to link training and work, using current and real work-related problems as the training agendas and work groups as the basic training unit. For farmers, their educational and organizational needs are usually much greater than those of technicians. Current training strategies for farmers tend to be centered upon the extension of technological services rather than upon training and education. The Ecuador ICRDP has been a notable exception to this whereby the Union has assumed specific training functions and responsibilities.

Forging links within and between regions and countries has been an important aspect in the implementation of the cassava research and development strategies. The project framework provides a forum for inter-change of experiences and methodologies and facilitates the resolution of problems that are common across regions and projects. Networking, at regional and country level has proven an effective means of allowing regions and countries facing similar problems and opportunity, to benefit from accumulated knowledge and experiences.

- **Crop production technology research.** Development of additional markets, products and uses for cassava will require the development and adoption of cassava production systems that will sustain or increase productivity while reducing costs and increasing cassava competitiveness. This process may require the introduction of more intensive farm practices that could place grater pressure on the natural resource base. Introduction of adapted genetic materials and a careful exploitation of alternatives for soil fertility maintenance and enhancement is required. Sufficient evidence exists proving that small-scale, cassava-based farmer organizations can function as an effective vehicle for production and processing technology adaptation and transfer.

- **Product and market development.** Up to now, most of the ICRDPs and product development activities have depended on a reduced number of market outlets, usually the traditional market (human consumption) and one or two alternative markets (animal feed or industrial uses). Recently, new industrial markets have been identified and new products have been developed. This in turn has stimulated greater attention to improve quality control and market financial management . The long term viability of the projects will depend on the ability of the farmers organizations to move their products into a wider range of markets and end uses, especially those than can offer a higher profitability margin (added value).

- **Monitoring and Evaluation.** Project monitoring and evaluation (M&E) activities have been an integral part of the ICRDP and product development strategies. M&E has proven to be essential for short run decision making in refining specific objectives, defining potential products, markets, research priorities and sites, beneficiaries, etc. In Colombia, adoption and impact study results have been fed back to research managers, scientists, farmer organizations, policy makers and donors, for different specific uses. In Brazil, coop-level processed data about their operation is being fed back to farmers'groups within a month allowing them to asses their own performance and to compare it with that of other groups.

- **Policy support and decisions.** Implementation of ICRDPs and product development activities are closely affected by and related to policy decisions and support. For example, all countries in Latin America are net importers of cereals and most governments have tried up until now to resolve increasing demand for carbohydrates through policy interventions and subsidized production schemes that have distorted markets. This has meant that traditional starchy staples such as cassava have had to compete with grains at substantial disadvantage. Exploitation of post-harvest opportunities for root and tuber crops is not currently a technological problem. The central issues in developing cassava-based markets and products is competitiveness of the whole process (production and market) and this is directly influenced by policy decisions which could either affect or strengthen the bargaining power and organizational levels of cassava producers. In Colombia, these issues have become very important during 1993-94 when the free economy and open market policy led to decreased import duties that allowed the importation of cassava pellets from Indonesia (20,000 tonnes), at dumping prices, representing a risk for the national dry cassava industry. On the other hand, with the current tendency of governments to reduce subsidies on imported flours, a favorable policy environment could be created in which cost advantages and specific quality attributes of the cassava-based products could facilitate the development of new products and markets.

6. CONCLUSIONS

The integration of cassava research and development activities through the ICRDP and product development strategies allowed CIAT to address these food securities issues. The experiences accumulated during the last 15 years in developing post-harvest cassava research and development activities for cassava processing and storage technologies in cassava farming systems as diverse an contrasting such us those of Northern Colombia, the province of Manabi at Ecuador and the State of Ceara in Northeast Brazil do not have an universal formula for success. Each project has been an unique experience. For every project, the results and its effects on food security issues have presented different forms:

In the Colombian ICRDP, food security of cassava farmers was enhanced through the introduction of an alternative market -dry cassava for animal feed- that stimulated adoption of improved technology and increased cassava areas. Increased incomes and additional employment opportunities were obtained. In urban areas, the effect was in the form of decreased fluctuation in cassava prices and urban consumers were able to purchase better quality cassava product at more competitive prices In Colombia, before the ICRDP project, food security was being addressed through donation of food (usually coming from developed countries) to each farmer household. The Colombian ICRDP implemented an interesting policy measure when the World Food Programme authorized selling the food and using the money to finance the construction of dry cassava agroindustries. This decision brought about food security to farmers households through the introduction of new technologies, products and markets.

In Ecuador, the main contribution of the ICRDP project to enhanced food security was represented in the strong market diversification component. The adaptation of the processing technologies to new markets generated incomes and additional employment opportunities for landless farmers, elderly people and children, usually the more vulnerable and marginalized sector of the rural population. These increased incomes resulted in increased purchase of food stuffs and other products in local shops in rural communities thus stimulating local growth.

In the Brazilian ICRDP, household level food security was catalyzed when cassava farmers started changing their commercialization and utilization patterns adopting the new processing technologies. Household level consumption of *farinha de mandioca*-their basic staple food- was increased significatevely when farmers started selling a portion of their production of cassava roots to the dry cassava agroindustries thus generating a cash income that could be used to purchase other food stuffs. Before the project, this product was the only commercial outlet and in many cases, due to low prices, a larger portion of the product had to be sold to make enough cash which in turn decreased their own consumption levels.

It has been clearly proven that when increased value for the cassava crop is created through the identification of new markets and the development of processes and products suited for these markets, farmers are willing to invest in improved production technologies. This has profound implications for the deployment of technologies that increase and maintain productivity without degradation of the resource base. Farmers and processors who have benefited from the value that new markets bring to cassava have an incentive to conserve the resource base and ensure that productivity is sustained.. They therefore become willing collaborators in redirecting efforts towards long term management of cassava farming systems as part of a resource management process that includes impacts on productive capability, water and waste management, and relations with complementary and competing systems. If these issues are incorporated into the ICRDP and product development strategies, there will be a greater chance of achieving long term benefits in the welfare of rural people who depend on cassava for their livelihoods.

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Table 1. Cassava technology component adoption[3] and subsequent cassava yields by different level of market influence in the North Coast of Colombia, 1991

	% of adopters		
	Average	High influence areas[4]	Low influence areas[5]
Technology component			
Variety Venezolana	52.8	87.2	37.2
Variety MP-12	2.2	6.6	0.4
Plant density	26.4	26.9	17.1
Stake selection	8.3	17.0	7.3
Stake size	0.6	1.6	0.5
Mechanization	28.5	36.4	15.6
Herbicides	27.9	47.2	15.1
1992 cassava yields			
		---------------------- t/ha--------------------	
Intercrop	9.2	9.7	8.7
Monoculture	10.4	13.3	10.8

Source: Henry et al., 1994.

Table 2. The dry cassava industry in Colombia. Distribution of total benefits. (1984-1991)

	US$ 000	%
Cassava producers	15,013	68.6
Feed manufacturers	4,334	19.8
Fresh cassava consumers	2,039	9,3
Dry cassava processors	1,150	5,3
Intermediaries	-0,662	-3,0
TOTAL BENEFITS	21,874	100,0

Source: Gottret & Henry, 1993

[3] Adoption of components since 1984
[4] Strata of cassava producers in areas with cassava drying agroindustries and strong institutional presence
[5] Strata of cassava producers without cassava drying agroindustries and low institutional presence

Table 3. Consumer panel evaluation of fresh and 2-week stored cassava in Bucaramanga and Barranquilla, Colombia. 1990

Characteristic	Bucaramanga		Barranquilla	
	Fresh	**2-week stored**	**Fresh**	**2-week stored**
General appearance of whole root (uncooked)	2.36	2.12	2.13	2.00
Boiled root:				
Starch content	1.75	1.68	1.96	1.96
Texture	1.60	1.46	1.78	1.78
Sweetness	2.97	2.95	2.00	1.65
General eating quality	2.21	2.23	2.39	2.43

Key: 0 = bad; 1 = fair; 2 = good; 3 = excellent

Source: Adapted from Wheatley et. al. 1990

Table 4 Results of food industry trials of cassava flour in a range of food products.

Product category	No. of industry trials	No. of positive results	% of substitution of wheat flour	Comments on product made with cassava flour
Processed meats	9	9	100	Better consistency, water absorption, good color
Biscuits/cookies	37	32	5-50	Firmer texture, good taste, crisper
Cakes	15	11	5-30	Good taste, good volume
Pastas/noodles	8	4	20-35	Good quality
Ice-cream cone	5	4	5-100	Firmer, maintains texture well
Packet soups	2	2	20-100	Good taste

Source: Ostertag and Wheatley-unpublished

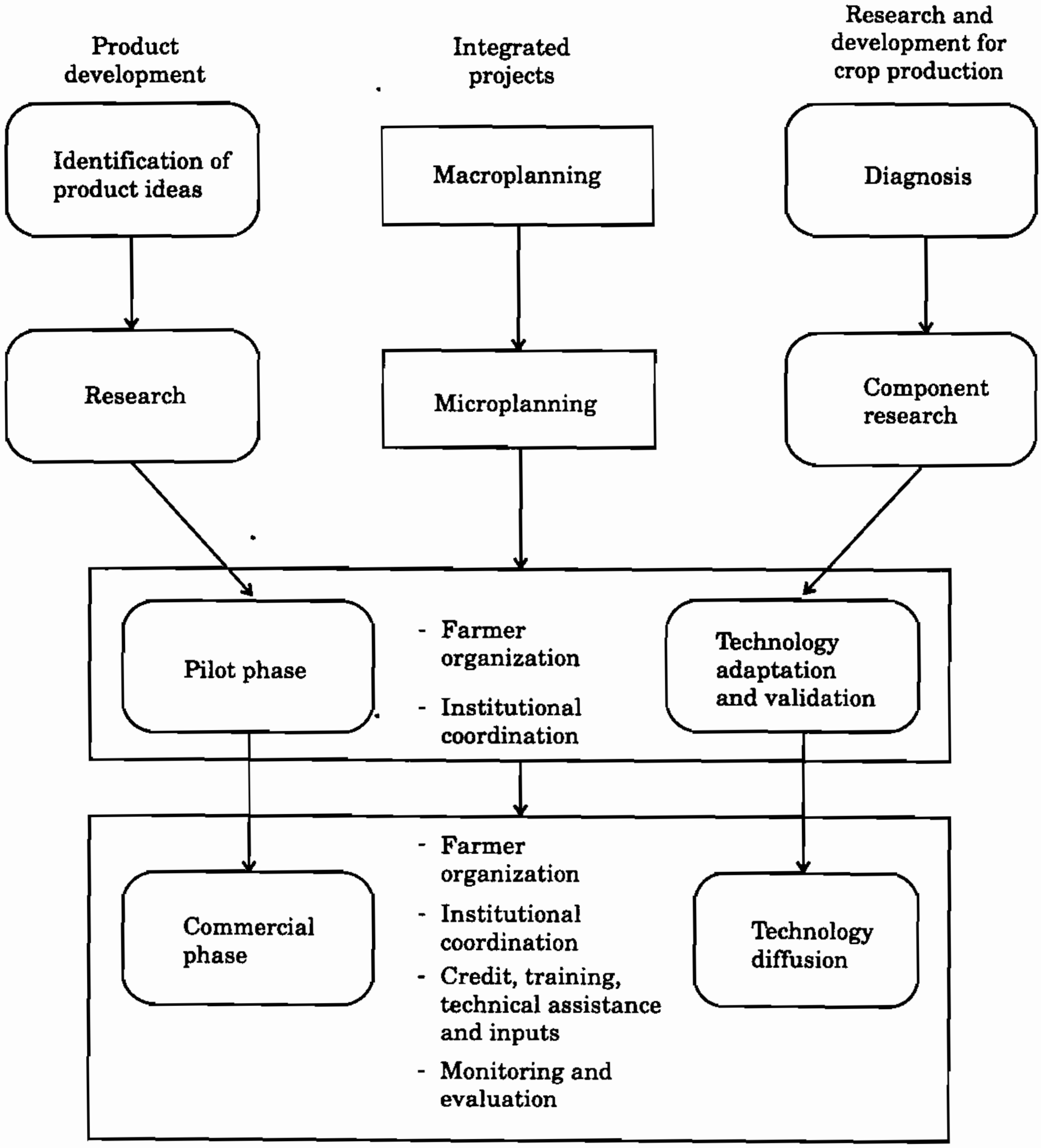

Figure 1. Flow showing the relation between ICRDP Product Development Methodologies.