Centre Technique de Coopération Agricole et Rurale ACP-UE
Technical Centre for Agricultural and Rural Cooperation ACP-EU
CTA

Adding value to cereals, roots and tubers

Developments and opportunities in small-scale enterprise development in Africa

Study Report



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A study commissioned by the
Technical Centre for Agricultural and Rural Cooperation (CTA)

STUDY REPORT

by

Domien Bruinsma

Technical Centre for Agricultural and Rural Cooperation (ACP-EU)

The Technical Centre for Agricultural and Rural Cooperation (CTA) was established in 1983 under the Lomé Convention between the ACP (African, Caribbean and Pacific) Group of States and the European Union Member States.

CTA's tasks are to develop and provide services that improve access to information for agricultural and rural development, and to strengthen the capacity of ACP countries to produce, acquire, exchange and utilise information in these areas. CTA's programmes are organised around four principal themes: developing information management and partnership strategies needed for policy formulation and implementation; promoting contact and exchange of experience; providing ACP partners with information on demand; and strengthening their information and communication capacities.

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Contents

Acknowledgements vi
Summary vii

INTRODUCTION 1

1 STORAGE AND PROCESSING WITHIN THE CONTEXT OF THE FOOD MARKETING CHAIN 5
Marketing systems 5
Food chain management 10

2 DEVELOPMENTS IN CEREAL STORAGE AND PROCESSING 13
Crop production 13
Storage practices 14
Threshing and shelling 16
Dehulling and milling coarse grains 17
Dehulling and milling rice 21
Secondary processing 22

3 DEVELOPMENTS IN ROOT AND TUBER CROP STORAGE AND PROCESSING 27
The food chain 27
Storage practices 31
Cassava processing 33
Potato processing 37
Sweet potato processing 38
Yam processing 40

4 DEVELOPING SMALL-SCALE FOOD PROCESSING ENTERPRISES 42
Technology selection and dissemination 42
Enterprise development 48

5 CRITICAL ISSUES FOR DEVELOPMENT 54
Storage and processing 54
Enterprise development 56
Further research 57

Annexe 1 Bibliography 59
Annexe 2 Food processing research and development projects 70
Annexe 3 Experts consulted during the study 87

Acronyms and abbreviations 89

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Summary

Storage and processing operations play an important role in the food chain, from agricultural production to consumption, whether the products are intended for household use or for the market. These operations may be based on traditional practices, they may involve the use of new or improved technologies, or they may be a combination of both. In most African households the processing of cereals, roots and tubers is a time-consuming activity. Generally, women are the processors, transforming these staple foods into traditional meals for their families. Of prime importance in food storage and processing is the prevention of loss and the retention or development of certain quality characteristics. Such characteristics vary from one region to another and depend upon the food processing methods used.

Developments in storage and processing operations occur for a number of reasons, the most important ones being the need to increase the supply of food, reduce labour requirements and generate income. Many of these developments have their origins within the household context. What today is a stage in household food preparation might tomorrow, through taking advantage of new technical and market opportunities, be the foundation for a small-scale commercially viable food processing enterprise. The investigation of such opportunities forms the basis of this study report.

Study objectives and report content

This study was commissioned with a twofold objective:

- To provide an overview of developments in storage and processing technologies for cereals, roots and tubers in Africa;

- To examine developments in the food marketing chain which may be of economic benefit for producers of cereals and root and tuber crops.

The main cereal crops covered in this study report are coarse grains (maize, millet and sorghum) and rice; the main root and tuber crops are cassava, potato, sweet potato and yam. The report provides an overview of the technologies for storing and processing these crops and discusses problems and opportunities in technology development and dissemination. However, when exploring the opportunities for producers to add value to their production of cereals and root and tuber crops, we should analyse the possible options within the context of the whole food marketing chain. Conducting a review of the technical developments that may provide new and better storage and processing technologies that increase efficiency, reduce labour requirements and reduce losses will solve only part of the problem. This approach may even lead to developments that are not viable, because products that seem to

be of a better quality may in reality not reflect consumer demand. Similarly, other options such as improving access to markets and increasing the bargaining power of producers (for instance, through better organisation) may be overlooked.

The report therefore pays attention first to developments in the food marketing chain. It then shows what practices and opportunities exist in terms of storage and processing technologies, and concludes with a discussion on aspects of enterprise development that may become important when applying processing technologies in an enterprise-oriented setting.

Study methodology

The information gathered for the study was derived from:

- A survey of the literature (research documents, project reports, etc.), in print and electronic form, including the SIS/SPAAR (AGRISEARCH) database and the CD-ROM abstracts services provided by AGRIS, AGRICOLA, CABI and FSTA. *See* Annexes 1 and 2.

- Interviews, visits and e-mail contact with specialists in various institutions (including ATSAF, CIRAD, IDRC, ITDG, KIT, NRI and TOOL) in cereal and root and tuber crop processing, technology dissemination and the development of small enterprises. *See* Annex 3.

For the purposes of the study, it was necessary to obtain information not only on promising technologies and the factors involved in the effective use of such technologies, but also on:

- The organisation of producers to help them increase profits from the storage, processing and marketing of their products;
- Interesting approaches for disseminating technology and fostering the organisation of producers;
- Opportunities and problems in enterprise development;
- Issues needing further research;
- Institutions and experts specialising in food storage, processing, marketing and enterprise development.

Thus the key issues studied and discussed with experts were:

- Storage and processing operations as part of integrated food chain management;
- The role of storage and processing in efforts to increase profits in the marketing of raw materials by farmers' groups;
- The organisation of interest groups in storing, processing and marketing their raw materials;
- Technologies which reduce the workload of women in food processing and preparation;

- Technologies which are an effective component of income-generating activities and enterprise development;
- Methodologies for disseminating technologies (including such issues as product and process development in a market economy, the application of participatory methods, and knowledge of a transaction framework).

Much of the literature mentioned in this report is concerned mainly with the development and introduction of the technologies themselves. At the time of the study there was comparatively little material available on the food marketing chain or on such concepts as integrated chain management and participatory technology development with regard to the African environment.

The study was carried out during the first half of 1996. In addition to this study, CTA contracted the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) to prepare two case studies: "L'évolution de la transformation du maïs au Cameroun" (Bom Konde, 1996) and "Entrepreneuriat et transformation du manioc au Congo" (Bazabana, 1996). Both the review study and the cases studies were presented at the CTA consultative meeting held on 29–30 October 1996 to review initiatives and proposals for strengthening small-scale food processing enterprises in Africa. The needs and constraints of establishing small-scale enterprises were analysed during the meeting and the following areas were highlighted:

- Management skills (bookkeeping, budgeting and organisation of groups);
- Information on available equipment (alternatives);
- Training in business planning and ways to obtain credit;
- Supply of market information.

The meeting recommended that future programmes should give more attention to facilitating entrepreneurs' access to credit, technology and business advisory services. In this respect, the training of facilitators in information service centres, consultancy services and research institutes should be more directed towards needs assessment, development of business plans and technology validation. The meeting recommended that CTA should support some studies and workshops involving the main stakeholders in the food processing sector to analyse specific problem areas and needs within countries, with the aim of developing appropriate strategies. Benin, Malawi, Senegal, Tanzania and Uganda were selected for such activities.

During a workshop on entrepreneurship development in small-scale food processing in Malawi, held in May 1997 (Würdemann and Meerendonk, 1997), it emerged that entrepreneurs in small and micro enterprises have difficulty in getting access to various services. This conclusion was also reached in a study on the small-scale food processing subsector in Tanzania and Uganda (Dietz *et al.*, 1998). Some services are available but there is clearly a need to improve them and fulfil a brokerage function between entrepreneurs on the

one hand and, on the other, suppliers of credit, technology and market information, and business advisory services. As a follow-up to the workshop in Malawi, a proposal was therefore made that information service centres for small-scale agro-processing enterprises be established.

INTRODUCTION

In large areas of Africa food processing, both for home consumption and for the market, is still household based. Commercial activities are limited mainly to food storage and trade. Apart from some industrial flour mills operating in the larger urban centres, small service mills and bakeries are the only widespread processing enterprises. This picture can be changed, however, by encouraging food producers to add value to their products by taking advantage of the opportunities to develop food processing and storage enterprises. The production of other products (horizontal diversification) and the development of other activities in the food chain (vertical diversification) are pivotal to the success of such enterprises. To identify appropriate products and activities, there are three important questions to be asked.

What can we learn from other products on the market?

Import substitution for well-defined market segments often offers opportunities for local enterprise development. For example, the Royal Tropical Institute (KIT), based in Amsterdam, The Netherlands, developed an approach to make a weaning food from locally available cereals, pulses and oil seeds following a simple and safe processing procedure. A pre-cooked porridge flour is produced by cleaning, roasting, mixing and milling the ingredients; the flour is then packed in plastic bags and labelled. Production units have been established in Benin, Burundi, Ghana, Malawi and Niger.

One lesson learned from these projects is that it is expedient to produce for both institutional and consumer markets. The production of a low-cost product for a specific target group should always operate on an economically viable basis. Nevertheless, by entering other markets it is possible to make use of the installed capacity and increase the profit of the enterprise. The Small-Scale Likuni Phala Production Unit in Malawi, for example, is now also producing breakfast flours and school feeding mixes for the market.

What can we learn from neighbouring markets?

An interesting illustration of this question is the Project AVAL in West Africa, developed in cooperation with the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), based in Montpellier, France. The project idea was born during a seminar in Cotonou, Benin. It emerged that the ways of processing maize and the range of maize-based dishes are far more diversified in Benin than in Burkina Faso. Project AVAL is studying local food processing practices and stimulating the exchange of information by organising enterprise-to-enterprise visits for market women and restaurant owners. These

business women see that they will benefit from such activities and are prepared to pay for them. Meanwhile, business women in Burkina Faso and Senegal are also being trained to produce new maize products selected by themselves and their customers. Women in Benin have received training from their counterparts in Senegal in the production of fruit juices and syrups.

In root processing, too, there are experiences which offer opportunities for enterprise development. Cassava can be used to make a fermented product such as *gari* (common in West Africa), a pre-cooked granulated flour akin to a convenience food. The importance of an intermediary cassava product such as *chikwangue* in the Congo lies in the fact that it is stable enough to be transported from rural production areas to the distant markets in Brazzaville. In Côte d'Ivoire, farmers produce *cossettes d'ignames*, yam tubers which have been dried to give the yams a longer shelf life. Most of these products are the result of a long tradition and the experiences of farmers, processors and traders. With increasing urbanisation, these and other products may find a bigger market as convenience foods, even in countries where they are, as yet, unknown.

What can be expected from product development?

Enterprise development in the secondary processing sector has sometimes failed because the approach taken was excessively technology driven. Many researchers now realise that a market-oriented approach is indispensable.

The development of composite flour products, made from local cereals, to replace wheat flour in bread is an example of the technology-driven approach. While it is possible to produce relatively good quality bread with a mixture of wheat and non-wheat flour, and even with a high percentage of non-wheat flour, most merchant mill and bakery owners consider that consumers prefer white wheat bread. In addition, price differences and the limited availability of good quality local cereals did not make it attractive for the flour milling industry to incorporate local cereals. Good results have been obtained only when real import restrictions have been imposed.

Couscous making is often seen as highly labour intensive and therefore suitable for mechanisation. Industrial equipment to make couscous from wheat flour has existed for a long time, but equipment to process local cereals on a small scale is lacking. An improved prototype of a cylindrical couscous-making machine, developed by CIRAD in cooperation with the University of Benin, was being tested in 1996.

Large quantities of fermented cassava starch are produced in Latin America to make bread-like products. Before such a product can be introduced to other parts of the world, however, a thorough socio-economic study of the whole food chain would have to be made, including, of course, a market analysis.

Quality

Quality plays a very important role in enterprise development. It relates to both the process and the product, and determines competitiveness in the market. Process and product quality is influenced by the availability and reliability of equipment, information services, training and organisation.

Product quality and consumer requirements

A few recent improvements in product quality along the food chain are of interest. Cassava, for example, is a perishable product that can be kept for only a few days after harvest. Based on needs assessment studies, an improved method for storing fresh cassava has been developed by the Natural Resources Institute (NRI) in the UK and transferred to farmers, traders, market women, restaurant owners and consumers. Good roots can be well preserved for more than a week by dipping them in water immediately after harvest and storing them in sacks, wrapped in polyethylene to retain the heat, kept off the ground and protected from direct sunlight. Losses along the marketing chain can be greatly reduced using this method.

The incidence of health problems due to cyanide exposure from insufficiently processed cassava illustrates the importance of adequate processing. Studies on improved processing thus involve extensive study of cassava's biochemical and microbiological characteristics, but sufficient attention must also be paid to the approach for selecting and disseminating the technology. Following studies of various traditional technologies, projects are now being implemented to introduce relatively fast and safe methods for processing bitter cassava in Mozambique and Uganda. For women in Mozambique it came as an eye-opener that, after peeling, grating, pressing out water and roasting, cassava could be eaten the same day.

The traditional production processes for many intermediate food products, made from cereals, include fermentation. Research to improve or upgrade such processes is addressing, for example, the development of starter cultures to improve and control product quality and to increase food safety during processing.

Local equipment manufacture

An advantage of having machinery made by local artisans is that better access to repair services and spare parts is provided. The dissemination of numerous processing technologies has been stimulated by local production. Manufacturing workshops, however, need technical support, assistance in the supply of raw materials and – what is very often lacking – assistance in product marketing and promotion.

In Senegal, local workshops now possess the technical skills to produce threshers, dehullers and milling machines. In contrast to many other West African countries, Senegal now imports

very few cereal mills. Other examples of processing equipment successfully manufactured locally are rice and sorghum dehullers, bakery ovens and oil expelling equipment.

Information and training

Activities to promote food processing and storage enterprises should include providing assistance on acquiring market information, selecting technologies and gaining access to credit. In Ghana the cooperation between training and consultancy institutes (the Technology Consultancy Centre of Kumasi University and Ghana's Regional Appropriate Technology Industrial Service) and workshops has been a successful instrument in enterprise development. Trade fairs and enterprise-to-enterprise visits, such as those organised through the Farm Implements and Tools (FIT) programme by the International Labour Organisation (ILO) and the Netherlands-based Technologie Overdracht Ontwikkelings Landen (TOOL), can also play an important role. All such activities, however, should be backed up by a network of information and inquiry services linked with local and foreign institutions.

Management systems and ownership

Backward and forward linkages in the food chain, such as group arrangements for input supply and marketing, contract farming, supply to processors on credit, and the use of inventory credit, are all issues to be studied when seeking to improve businesses.

For example, women cassava processors in some West African countries have experience in organising themselves into groups for the supply of raw materials and part of the processing (generally grating), whereas other activities such as peeling, roasting and marketing tend to be carried out at the individual level. At the village level, processing using equipment owned by a cooperative is not always the best solution. It may be feasible to work with equipment leased from a nearby workshop which will be able to handle more complex maintenance and repair and supply spare parts.

A well-known example of farmers organising themselves to undertake group activities in the food chain is the village cereal bank. Nevertheless, some internal factors are essential for the successful operation of such farmer-controlled enterprises. The factors highlighted in NRI studies include: a clear member-driven agenda; purely financial objectives; and a high degree of self-financing. Although the role of facilitators is important it should be limited mainly to providing advice and assistance when asked for.

Finally, it should be noted that food chain management is receiving more and more attention worldwide. The focus is on cooperation between different actors in the food marketing chain, aimed at reducing transaction costs and adapting production to consumer demand. Studies need to be done on how the related management and marketing concepts can be applied to agricultural and rural development in a rural economy.

Chapter 1

STORAGE AND PROCESSING WITHIN THE CONTEXT OF THE FOOD MARKETING CHAIN

The processing of cereals and root and tuber crops does not seem to be very diversified in Africa. Although side dishes may vary from region to region and throughout the year, the staple food is generally consumed the same way – as a porridge or paste prepared from cereal, root or tuber flour or from fresh roots or tubers. The methods of pre-treatment, however, vary considerably. Flour and paste preparation usually takes place at the household level and is carried out by women, demanding considerable time and energy. Commercial activities in the food chain tend to be limited to the storage and trade of whole durable grains and, to a lesser extent, dried root and tuber flours. Processed and prepacked products are not available in large quantities in the market, possibly because of the low purchasing power of most of the population. Only in larger urban areas do the conditions exist – sufficient purchasing power and variation in consumption patterns – for marketing refined products such as flour, grits, couscous and pasta. Service mills are generally used as a support to household-level processing, with large mills being viable usually only when flour production is subsidised by government. Roots and tubers are less durable and marketing is dominated by the trade in fresh crops and dry flours produced in or near agricultural production areas.

The overview of developments in this chapter and in Chapters 2 and 3 should be seen against the background of this traditional environment. Examples of small-scale producers adding value to their products through processing are still the exception rather than the rule. The discussion in this chapter focuses first on the decisions facing producers with regard to different marketing systems. It then looks at the implications for organisation and the options for cooperation within the marketing chain.

Marketing systems

Farmers produce food crops both for their own food supply and to sell in the market to earn an income. In either case, they could decide to store and/or process the crop for preservation purposes or to add value to the crop by extracting valuable components or producing composite products from it.

When marketing a crop, farmers have three options:

- *Direct marketing of the harvested crop.* This is the least complicated option. The farmer deals with traders who come to the village or the farm, or takes the crop to the market and sells

it to traders or consumers. Decisions need to be made on transport, which often presents difficulties, and on whether to sell the crop as part of a cooperative or other organisation in order to increase profits.

- *Temporary storage before marketing the crop.* This option gives the farmer the opportunity to increase profits by taking advantage of market price fluctuations. It can be organised at individual or community level in cooperatives or economic interest groups. Some form of credit or bank loan is likely to be necessary because after harvest various costs have to be met.

- *Processing the crop before marketing it.* This is the most complicated option. It requires knowing what products will be marketable; selecting, investing in and installing processing equipment; undergoing training in operating the equipment; and organising the supply of raw materials to be processed. Thus it requires greater management and entrepreneurial skills than is the case for the first two options.

When studying opportunities for improving the production and marketing of traditional food products it is necessary to analyse the existing distribution systems, why these systems are as they are and how they function. A useful example of this is the detailed study conducted in the Congo by Bazabana *et al.* (1995) on the production of fermented cassava dough in rural areas for the market in Brazzaville. A similar system exists for *gari* production in some West African countries, and yet there do not appear to be such systems for couscous or other rolled products made from cereal flour. Of course, the perishability of cassava, from which *gari* is made, would be a factor here. What is not clear, however, is why in some urban centres consumers buy products such as *gari* produced elsewhere but in a comparable urban situation they will make a product such as couscous themselves. In general, consumer behaviour in Africa has not been the subject of much study (Beck, 1995).

In helping farmers establish and organise marketing systems, among the most useful forms of assistance would be to help them assess ways in which they can improve their access, individually or collectively, to various services (such as input supply, credit schemes and marketing information and advice) on a sustainable basis (Coulter, 1994). Issues that may need consideration include:

- Improvements in individual on-farm storage;
- Group arrangements for input supply and marketing;
- New savings and credit arrangements;
- Road building programmes;
- Organisation of produce auctions.

A project aimed at improving market organisation was initiated recently by the Natural Resources Institute (NRI), in collaboration with the UK Department for International Development (DFID), the Food Studies Group at Oxford University, Kew Botanic Gardens and Silsoe College. Issues likely to be important in this project include:

- Low-cost (or no-cost) storage;
- Marketing innovations such as contract farming and outgrowing schemes, and marketing organisation in general; auction-like systems may also be considered (P. Hindmarch, pers. comm.);
- The need for interim credit support.

Caution should be taken, however, when introducing schemes to improve farmers' storage and marketing arrangements. It is useful in this regard to look at one example of village-level organisation of storage and marketing – the cereal bank.

Over the past two decades various projects have introduced cooperative cereal banks in villages with the aim of ensuring that there is enough grain in the village during the cropping season and before the new harvest is available. These arrangements tend to be based on outside credit ("inventory credit"), on villagers' contributions and/or on the proceeds of harvesting a communally owned field. Cooperative cereal banks have proved to be profitable in the Sahel region where profits range from 13 to 20% (van Wijk, 1993) or 1 to 15% (van Altena, 1998). Cereal banks often also have a stabilising effect on price levels (Yonli, 1997). However, they are not always successful. Studies by van Wijk (1993) and Yonli (1997) have highlighted various conditions for success:

- The criteria for the selection of villages in which a cereal bank is to be located are important. A village should have a certain coherence and a capacity to manage investments at community level;

- The availability of financial resources considerably influences the success of a cereal bank. In a village that is poor in terms of production performance and financial resources, a cereal bank is unlikely to change the village's fortunes radically;

- Proper emphasis needs to be given to extension efforts, training in storage management, bookkeeping and village-level trade policy. Factors involved in managing food stocks in relation to fluctuations in cereal production are described by Yonli (1997);

- Subsidies should be reserved for storage structures and utensils such as weighing equipment;

- Credits should be provided in such a way as to prepare villagers for integration into formal credit systems;

- After the installation of a cereal bank, there should be a test period during which villagers learn how to manage the bank and develop good buying and selling policies.

A relatively new concept is the integration of several cereal banks operating jointly in the cereal market. More research is needed to assess the potential and constraints of this type of

cooperation. In some West African Sahelian countries a French NGO, Afrique Verte, is helping to establish federations of cereal banks that trade at a stock exchange of cereals. Such a stock exchange can be particularly important at times when some cereal banks are in regions where there is a crop surplus but others are in areas where there is a deficit (Yonli, 1997). The experiences with a cereal stock exchange in Burkina Faso have so far been positive (C. Jongkamp, pers. comm.); although the trade is fairly small scale, prices are negotiated and announced in public, and this has a regulating effect on other markets in the country. General information on cereal banks is provided by Kat *et al.* (1992).

Persuading financial institutions to take risks with small-scale producers is still a problem, but there has been some progress in recent years. The experience with "inventory credit" in Ghana is an example of this progress. Under this system, credit is given using agricultural produce as collateral. Coulter and Shepherd (1995) stress that transactions under this system should profit both lender and borrower. Also, in order to attract financial institutions to this form of credit, it is essential to have reliable warehouse operators. The ingredients for a successful inventory credit scheme have been analysed by the NRI and the Food and Agriculture Organisation (FAO), drawing on experiences in Ghana, India, Mali and the Philippines (Coulter and Shepherd, 1995).

Other research by Coulter *et al.* (1995) has shown that farmer-controlled enterprises (FCEs) can be an effective channel for lending in relation to cash crops. Case studies have also shown that FCEs can successfully provide marketing and processing services, but the reasons for this success need to be carefully analysed. Success is less dependent upon the support of an outside agency, such as a bank or an NGO, than upon the motivation and intrinsic qualities of the group members and the cultural context in which they operate. The failure of FCEs is extremely common, and in no sense can successful groups be "programmed" by an outside agency! The case studies indicated that among the internal factors that are associated with success are a clear member-driven agenda, purely financial objectives (rather than broad social objectives), and a high degree of self-financing.

Further study is necessary on developing group approaches to marketing and on how to sustain more complex group activities, such as processing, over the long term. In the meantime, however, the above list of factors for success can be extended by quoting Harper (1992), who analysed a great number of workers' cooperatives and noted the following lessons:

- The successful groups came together on their own, rather than being pushed together by outside advisors;
- Once the groups had started, the successful ones were not compelled to adopt certain work practices or forms of organisation;
- Successful organisational structures have to be evolved by the people who work in them, they cannot be imposed by outsiders;

- A number of the more successful groups received training, but it was generally training in the subjects they asked for and some of them had to ask many times before they received the training they wanted;

- There are good economic and managerial reasons for group enterprises not to grow too large, and outsiders should not impose or even suggest enlargement of groups, or even maintenance of existing numbers; the members themselves must decide with whom they want to work;

- Training and advice should consist of telling members about what options are available, rather than telling [them] what to do;

- Agencies which make grants or loans are often tempted to provide more funds than the enterprise is able to manage. It is better to allow a group to grow organically by reinvesting the profits in new assets at a pace they can manage;

- Assistance agencies can also help with marketing, but it is important not to buy, or worse still force others to buy, the products of group enterprises which are not competitive in price or in quality;

- The final conclusion is perhaps the hardest to accept; freedom implies freedom to succeed but also freedom to fail, and groups must be allowed to fail. Assistance should be temporary, and cost-effective, so that it helps people to be free.

The conclusions reached in a study on the horticultural sector in Kenya provide a useful guide to other factors that need to be taken into account in group marketing activities (Dijkstra and Magori, 1995):

- Production planning should be market-oriented, whether for perishables or processed products, and the costs involved in storage and processing should correspond to the real market value of the products;

- Proper storing, grading and packing reduce losses and increase the profits in marketing;

- Roads and transport should be adequate; although major roads are the responsibility of the government, minor roads can be improved or maintained by the local community;

- Credit should be available to finance various activities and purchase trucks for transport;

- By organising themselves into groups to market products, farmers will become less dependent upon middlemen;

- The facilities of a market place should at least include a concrete floor and they should be maintained using market fees;

- Access to price information is very important; this factor is cited by Dittoh (1994) as a major determinant of successful market integration and marketing efficiency; governments need to give priority to the regular collation and dissemination of food crop marketing information, especially prices.

Arrangements to reduce risk, such as access to credit facilities at times when a group is facing difficulties beyond its control, should be an integral part of its operations. Platteau *et al.* (1985) provide examples of such credit arrangements in the case of fishermen who need to compensate for the differences between large and small catches or no catch at all.

Food chain management

Chain optimisation can be an efficient tool in the development of food processing and marketing (Hagelaar, 1994). The improvement of each step in the food marketing chain should be analysed and monitored in relation to other links in the chain. Optimising in this way the relationships within the chain demands good cooperation between the different actors in the chain. The management of this improvement process is called chain management, and the cooperation between different actors can be seen as "value-adding partnership". Chain management, however, is not the same as chain integration whereby individual enterprises lose their autonomy because they merge or are taken over by others above or below them in the chain.

In an analysis of developments in food chain management in Europe, Zuurbier (1991) noted some of the reasons for the greater emphasis on cooperation with other actors in the food marketing chain. Many of these are as applicable to the African context as they are to Europe. These include:

- Reduction of transaction and coordination costs through better organisation;
- Greater access to information about new technologies, as well as to the technologies themselves;
- Reduction in uncertainty about actions that other individuals or groups in the chain may take;
- Possible increased competitiveness;
- Reduction in logistical problems regarding the handling of perishables that otherwise may lead to loss of product quality.

The food marketing chain is now attracting greater attention from agencies involved in agricultural research and rural development. At a workshop on small-scale food processing and food security, sponsored by Deutsche Stiftung für Internationale Entwicklung (DSE) and Arbeitsgemeinschaft Tropische und Subtropische Agrarforschung (ATSAF), it was stressed that more attention should be paid to food crop marketing and utilisation (Richter *et al.*, 1996). Other international organisations, such as the Technical Advisory Committee (TAC) to the

Consultative Group on International Agricultural Research (CGIAR), are taking the view that research on agricultural productivity needs to be complemented by more research on product utilisation and post-production activities – storage, processing and marketing – as part of a coherent approach. Consumer systems differ from producer systems, but they can no longer be excluded from priority setting for international agricultural research. The consumer-oriented approach is already playing a more important role in research conducted by the NRI, the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) and the Royal Tropical Institute (KIT). The International Institute of Tropical Agriculture (IITA) is active in the development and dissemination of small-scale technologies but along with other CGIAR institutes such as the International Rice Research Institute (IRRI) and Centro Internacional de la Papa (CIP), it could do more in this respect in collaboration with national research organisations and private manufacturing and processing companies. CIP has taken steps in this direction with regard to product development for root and tuber crops (Scott *et al.*, 1992c; Wheatley *et al.*, 1995), as noted in Chapter 3.

Chain marketing

An important aspect of chain optimisation is chain marketing, defined as cooperation in marketing throughout the whole chain. Chain marketing, however, can be developed in Africa only under certain conditions: when agricultural production becomes more market driven and less production driven, and when the emphasis in marketing strategies is on "focus" rather than "differentiation" (Meulenberg and Kool, 1994). This will generally be the case more for the export market than for the domestic market. For the same reason, product auctions, which are an effective instrument in the marketing of perishable products in Europe, will be less effective in Africa. They work well only when consumer markets differentiate between the quality of products and demand a well-organised infrastructure (Houtkamp and van der Laan, 1993). This does not mean, however, that product exchange is of no value for the trade in cereals and root and tuber crops in Africa.

Quality assurance

Another concept that is of great importance to the optimisation of the food marketing chain is quality assurance. The concept involves instituting measures at all stages (production, processing and trade) of the marketing chain to ensure that the marketed product is demanded by and safe for the consumer. Thus quality characteristics, as defined by the consumer, determine what product should be produced and marketed, and at every stage it is necessary to analyse what is required to obtain the desired quality. In practice, most of this analysis takes place during and after the processing stage.

With regard to food safety issues in food processing, an important quality assurance tool is the Hazard Analysis Critical Control Point (HACCP) system. Developed by the food industry

to prevent or control food hazards in order to improve food safety, it is now widely used. It identifies specific hazards and the measures to control or prevent them, and thus reduces reliance on end-product testing. HACCP can be applied at any point in the food marketing chain and is very important for small-scale food processing and marketing operations. It has been used, for example, by FAO in efforts to prevent contamination in the production and selling of "street foods". HACCP methods are considered to be the most effective and efficient ways to enhance food safety, and the principles upon which they are based are used in establishing food safety standards in international trade (Casadei, 1996). Supermarkets, for instance, are increasingly urging their suppliers in many countries to use management tools based on HACCP and Good Manufacturing Practice (GMP) in order to be assured of the right quality products. This kind of vertical quality assurance becomes common practice in the food marketing chain.

Chapter 2

DEVELOPMENTS IN CEREAL STORAGE AND PROCESSING

The crops covered in this chapter are maize, sorghum, millet and rice. To provide some background to the discussion on traditional and improved processing technologies for these crops, it is necessary first to outline the current situation with regard to crop production and how this affects the development of processing technologies. The discussion then moves to storage practices and developments. The bulk of the chapter provides an overview of processing operations, including threshing and shelling, dehulling and milling, and secondary processing. More information on cereal processing and utilisation is provided in the bibliography, including FAO (1989a), Asiedu (1991) and Bencini and Walston (1991).

Crop production

In many agricultural development programmes, particularly in Southern Africa, the production of sorghum and millet has tended to receive less support than maize production. These programmes have often been defined primarily in terms of maize production incentives. In some countries, production inputs have been subsidised to encourage the use of improved maize varieties and production methods, and subsidised credit has enabled marketing authorities to purchase maize surpluses. In addition, maize consumption has been encouraged not only through subsidised retail prices but also through the distribution of maize meal in drought-relief programmes.

The preference for maize over sorghum and millet in agricultural development strategies stems partly from the problems associated with processing sorghum and millet. Hammer-milled sorghum is generally of poor quality, and this led the International Development Research Centre (IDRC) to promote the introduction of small grain dehullers (described below). Valuable information on this strategy is provided by Schmidt (1992), but it is not yet known whether the introduction of dehullers in rural areas has influenced the production of coarse grains. The dehullers may lighten the workload of women and children, make cultivars with a high tannin content more palatable and nutritious and foster urban demand for surplus production, but it is not clear to what extent and under what conditions this would be the case.

Although sorghum is traditionally used in considerable quantities for making beer, the brewery industry uses it only in relatively small quantities as a flavouring ingredient or a source of malt. Sometimes, when sorghum is temporarily cheaper than maize, larger quantities are used but generally maize is cheaper. Most other uses of sorghum and millet

depend upon their price compared to maize, wheat and barley. The use of white sorghum in the milling and baking industry is technically possible, and in some countries there is an urban demand for milled sorghum. As long as the world economic environment remains unfavourable to local cereal development and marketing in developing countries, however, the milling industry will not invest in processing sorghum and millet on an industrial scale (J. Faure, pers. comm.).

The demand for sorghum and millet by the animal feed industry is also potentially high, but again this potential will not be realised so long as maize remains cheaper. There is, however, a possibility that this may change because the subsidisation of grain production and market systems is considered to be unsustainable. Markets are now liberalised and maize meal subsidies have been withdrawn. Sorghum and millet remain critically important food security crops, especially in drought-prone areas, but productivity must increase significantly if they are to compete with maize (GASGA, n.d.). In addition, more research needs to be done on consumer preferences with regard to taste, texture and colour, on comparative evaluations with imported processed products, on reduction in tannin content without affecting bird resistance characteristics and on reduction in aflatoxin susceptibility (Mosha, n.d.).

Rice production in various African countries, particularly in West Africa, has benefited from considerable research on productivity and from the establishment of large-scale irrigation schemes. This has stimulated interest and investment in the development and application of processing technologies.

Storage practices

Grain needs to be dried quickly and effectively after harvest and prior to storage if maximum quality is to be retained, infestation by insects and micro-organisms minimised and germination prevented. Natural drying methods by sun and wind are not always adequate. Crop maturity does not always coincide with a suitably dry period, and high-yielding varieties and multi-cropping techniques demand alternative drying methods. Mechanical dryers, such as the batch dryer developed by IRRI, are finding increased application.

The main purpose of establishing centralised facilities to receive grain from farmers is to provide a buffer between the produce sold after harvest and the produce which reaches markets or consumers. There needs to be better appraisal, however, of the improvements that might be expected from the establishment of large-scale storage and handling facilities. Feasibility studies often forecast a greater reduction in losses than turns out to be the case. Also, many storage facilities were built to support government monopolies, and these are now no longer needed or are poorly located. At farm level, the adoption of new storage technologies has often been lower than expected. In some cases projects failed because they were based on the incorrect assumption that storage ranked high on farmers' priority list (Proctor, 1994). General information on storage practices and the possibilities for

improvement is contained in a number of publications, including NAS (1978), WFP (1983), Gwinner *et al.* (1990) and Proctor (1994).

Traditional storage methods at producer level are usually well adapted to the types of grain for which they are intended and the environment in which they are used. Thus storage losses are generally not high at farm level, especially in arid and semi-arid regions. Traditional methods of minimising loss include the use of certain herbs, an admixture of sand or wood-ash and sometimes the use of sealed containers. Overall losses over one year's storage are often only 3–4%. Investment in improved storage structures and in the use of insecticides may therefore be profitable only for long-term storage. In general, when introducing "improvements" more research should be conducted on the economic and social factors involved.

In humid areas grain losses may be higher than in arid or semi-arid areas, and the introduction of ventilated (crib-type) storage structures developed by the African Rural Storage Centre at IITA is appropriate for optimising maize drying and storage (FAO, 1987), but spraying the stored maize with insecticides is essential when using these structures. Rat guards on the legs of wooden stores and treatment against termites are also effective.

The need for changes in traditional storage practices may arise from several factors. Problems generally arise when introducing new varieties that are more susceptible to insect attack or when introducing new storage practices, such as storage in cereal banks at village level. Another important reason for change is the growing shortage of the materials traditionally used to construct grain stores. In these cases, assistance in food loss prevention methods may be needed. The NRI has long experience in providing this type of assistance. Some recent NRI-supported studies on optimising the use of fumigants in storage have focused on:

- Reducing the rate of the use of methyl bromide, which causes ozone depletion and will be banned in industrialised countries by 2005; by 1998 its use had to be reduced to 1991 levels. It is possible, if fumigation is conducted efficiently, to reduce the application of this fumigant at local level because overdoses are often used;

- Analysing the apparent increase in resistance to phosphene. Studies have shown that it is not increased resistance that is responsible for observed insect survival but inadequate training and management in the use of this fumigant;

- Developing and testing a system for the safe use of phosphene by small-scale farmers, using air-tight clay silos.

Other NRI-supported studies have focused on replacing conventional chemicals, such as the organo-phosphoric compounds. These include:

- Surveys in Malawi and Ghana on plants used to protect stored products, assessing their toxicological effects and how improvements can be achieved;

- Studies on the use of inert dusts. Dusts sprayed on the walls of storage facilities or mixed into stored grain can be effective in controlling insects. These techniques are cheap and, in Australia, have proved popular, but they are appropriate only in small-scale, farm-level storage and in low-humidity conditions;

- Studies on insect growth regulators. These regulators are effective for controlling insects in cereals but not in pulses. They have no immediate effect on adult insects and thus are appropriate only for long-term storage.

The use of insecticides to protect stored grain, however, is likely to increase, particularly for high-yielding varieties and where the larger grain borer is present. A series of recommendations and options have been developed for protection against the larger grain borer, and farmers can choose the option most suitable for them. A method commonly used in Tanzania involves the use of actelic-super dust; actelic is an organophosphorus compound mixed with pyrethrum. Another option available to farmers is biological control through the use of the predator, *Teretrisoma nigriscens*, which has been introduced from South America into Ghana, Kenya and Togo. Useful information on protection against the larger grain borer is provided in a leaflet co-published by the Groupe d'assistance aux systèmes concernant les grains après récolte (GASGA) and CTA (GASGA, 1993).

When introducing cereal banks (for example, as part of inventory credit schemes), care should be taken to ensure that the right technology is being used. Often, this technology will involve fumigation and spraying with insecticides. Without careful organisation and extension when introducing the technology, large storage losses may occur and farmers will soon become disillusioned. It is difficult to suggest specific recommendations; each technology must be tested for its suitability to the particular conditions involved. Useful information on the pest and on store management is contained in the FAO manual *Guidelines for the Establishment, Operation and Management of Cereal Banks* (Kat *et al.*, 1992).

Threshing and shelling

Manual threshing by pounding, when the cereal is intended for household consumption, is still very common in rural areas in Africa. For millet, manual threshing results in a very low throughput of about 10 kg/day/person. Storage and threshing practices may vary considerably. For instance, in some villages in southern Mali millet is stored as grain, but in other villages, sometimes in the same area, it is threshed only when sold or taken from the store for household consumption. It would be interesting to discover the reasons for this difference in approach and to exchange such knowledge.

Mechanical threshing of millet was introduced in the 1960s and 1970s in Senegal but was not adopted, and there has been little enthusiasm for pedal-operated threshers (M. Havard, pers. comm.). Hand shelling of millet is not very efficient (10 kg/h, with losses of about 20%), but

hand shelling of maize is becoming more widespread (Mbengue and Havard, 1992). Many of the small motorised threshers that have been introduced have proved to be too small to produce enough for marketing, preventing recovery of investment costs. The only type that works well for millet is the French "Bamba" model, which is widely used in West Africa; it is also used for other cereals.

For rice, threshing machines are now commonly used. The introduction of the "Votex" Ricefan may illustrate this phenomenon. When introduced in Mali the Ricefan soon replaced the large conventional tractor-driven threshers. There were in 1996 over 700 of these Ricefan threshers being operated and managed at village level in Mali. They are estimated to cost less than 5% of the paddy rice produced (A. Wanders, pers. comm.). The demand for these threshers outside Mali is slowly increasing. Local production of the Votex Twinfan started recently, and about 50 of these units were in use in 1996. They have the same capacity as the Ricefan model (about 8 tons/h) but the losses are reduced to almost zero.

Other rice threshers, such as the Sismar "Borga" model and combine harvesters, demand a larger investment than the Votex threshers. Sismar is a Senegalese manufacturer of agricultural machinery and processing equipment. In general, those providing threshing services are paid 5–10% of the crop value (Proctor, 1994).

Dehulling and milling coarse grains

Manual processing

Traditionally, grains are pounded to dehull them. About 5–10% water is added during dehulling to prevent breakage and to ease the separation of the hulls. After separation, the grains are pounded again and/or ground between stones to produce flour. It is a slow process, producing about 2 kg of flour per hour.

Several initiatives have been introduced to increase the efficiency of manual dehulling and milling. The NRI Agro-processing Group is developing a method aimed at improving dehulling at the household level. It involves adding (ash)lye when humidifying the grain for manual dehulling. Another initiative, aimed at improving the effectiveness of pounding, involves fixing a metal plate or ring on the top of the pestle. Tests on this pestle by Appropriate Technology International (ATI) in Senegal showed a 25% increase in efficiency (time reduction) but it is doubtful whether women in general will see the technology as a significant improvement. The metal plate or ring has not, in any case, been adopted spontaneously.

Such initiatives should be considered because mechanised mills are not within everyone's reach. In some remote areas manual disc mills are still in operation and are still sometimes requested; this is the case in Zambia, for example (A. Wanders, pers. comm.). Compared to

mechanised mills, these mills do not offer a significant increase in labour productivity, relative to investment. Women see manual mills as only a minor improvement compared with traditional pounding. Earlier attempts to introduce manual and pedal-operated mills in Tanzania met with a poor response. The mills were all rejected for maize milling and only the "Atlas" mill, for softer grains such as sorghum, millet and wheat, was adopted (CCT, 1980).

Limited attention has been given to dehulling and milling problems in other cereals such as *acha* (also known as *findi* or *fonio*), in which the main problem is dehulling. Developments in mechanised dehulling and milling in Mali, Nigeria and Senegal have been described by Goïta (1994), Jideani (1990) and Sanogo (1995), respectively.

Small-scale processing

Over the past 50 years mechanised milling has been introduced in various ways into African countries. The most common mechanised mills in West Africa are plate mills, used in urban and rural areas as service mills; hammer mills are also found in the region. In Eastern and Southern Africa hammer mills are more common as service mills for grains but most of the maize flour is produced by medium- or large-scale roller mills. Roller mills as used in maize milling originate from the technology developed in the wheat milling industry. Most mills, both at the small and larger scales, are operated on a commercial basis.

In some African countries mechanised mills have been introduced at village level by development programmes and are often cooperatively owned and operated. In West Africa, these mills generally operate profitably in villages with a minimum of 1200 inhabitants (Herzog, 1985). To make the mills affordable to more women and to smaller villages, several approaches have been tried. These include the introduction of animal-powered mills. Trials have been carried out in Burkina Faso, Mali and Senegal but no data on the extent of adoption have been found in the literature. Another interesting approach being developed by a United Nations Industrial Development Organisation (UNIDO)/International Fund for Agricultural Development (IFAD) project based in Burkina Faso and Mali aims to reduce milling costs by adding other equipment such as a battery charger and a forage cutter to the same diesel engine. The initial results are promising.

Although the dissemination of mechanised milling technologies started in Africa in the 1950s, there are still many villages without a mill. Mechanical dehulling began only in recent years, and is gradually spreading in various countries.

An important aspect of mechanisation is the need for local equipment manufacturers to provide spare parts and maintenance facilities (this issue is discussed in greater detail in Chapter 4). In Senegal such facilities are, to a large extent, locally available for threshing and coarse grain dehulling and milling equipment. In Botswana service milling and dehulling are widespread but in many other countries abrasive disc dehullers are not yet common. The

small Engelberg-type dehullers found in some countries are used not only for rice but also for coarse grains. The cereals are humidified to achieve effective hull separation but this causes great friction and therefore much higher machine power consumption and wear and tear than is the case for rice.

In the 1970s the Canadian International Development Research Centre (IDRC) began developing and testing a sorghum dehuller based on the use of abrasive discs that gradually grind off the hulls. The first models were tested in Botswana, Nigeria and Senegal. In Botswana they had a capacity of about 5 kg per batch, adapted to the needs of local service mills. The successful introduction of dehulling and milling units in Botswana is partly attributable to the prolonged periods of drought in the 1980s; this led to increased interest in sorghum and the government introduced policies supporting small-scale industrialisation (Schmidt, 1992). Limitations on wheat imports and the regulation of the sorghum market, which resulted in stable sorghum prices throughout the year, also stimulated the adoption of sorghum dehulling and milling units (Berbari *et al.*, 1991). Many of the service mills evolved into small-scale commercial milling enterprises, producing and selling a packed, processed product. It has been reported more recently that many of the mills established in the 1980s are now severely under-utilised (Schmidt, 1992).

A smaller version of the sorghum dehuller, the Mini-PRL dehuller, was designed during the second phase of the IDRC project in Botswana. This technology was transferred to West Africa, where it was adapted to local service milling conditions in which only small quantities (a few kg) needed to be dehulled at a time. In Zimbabwe the opposite happened again. In 1985 an NGO, Environnement et développement du tiers-monde (ENDA)-Zimbabwe, lengthened the barrel of the Mini-PRL and added a trap door for easier emptying of the batches. ENDA has sought to match the barrel capacity to the common 20-litre containers in which women usually bring their grain to the service mills (Schmidt, n.d.).

In Senegal several types of dehulling milling machines have been introduced. The CIS III (produced by Sismar) and the models produced by local artisans work on a batch-by-batch basis (less than 8 kg/batch). The CIRAD-SAR model works on a continuous basis (50 kg/h). It is being manufactured and promoted on a commercial scale by a company called Electra (Cruz and Havard, 1994).

The Mini-PRL dehullers appear to be suitable currently for service milling in peri-urban areas. In rural areas, however, dehulling is not yet perceived as a priority, but this may change in the future. In Mali there is evidence that, increasingly, young women prefer to live in a village where there is a mill (Sandhu, 1993). In Senegal some years ago rural women ranked milling at the top of their list of priorities for expenditure, but placed dehulling seventh, after other priorities such as clothing and school fees. This may have changed as there appears to be increased interest in Senegal's rural areas in mechanical dehulling. More information will emerge from the tests with dehullers being carried out in various rural locations (M. Havard, pers. comm.).

Semi-industrial milling

Three cases of the introduction of semi-industrial milling in West Africa were studied by CIRAD (B. Bridier, pers. comm.). In general, the units include pre-cleaning (dry abrasive disc) dehulling, milling and often sifting operations, but investment costs seem to be relatively high: depreciation accounts for about two-thirds of the value added. Two units have been developed for rural areas: one by the Cerecom company in Mali, in collaboration with the Compagnie malienne pour le développement des textiles (CMDT), and the other by the Société pour le développement de la filière de textile (SODEFITEX) in Senegal. The units can put through about 1.2 tons maize/day and need an independent power supply. They make use of imported equipment. The Senegalese unit, developed under the Comité de Sécurité Alimentaire (CSA) programme, is equipped with an electric motor (for urban areas) and makes use of locally manufactured equipment. The cost of this equipment is consequently significantly lower. At the time of this study, eight of these units were operating in Senegal and seven more were being built. All of them will be operated by private entrepreneurs already active in the cereal trade, some of them as millers.

Studies on the economic factors affecting the operation of semi-industrial mills in Botswana, Malawi and Zambia were conducted by Berbari *et al.* (1991). They indicated that the successful operation of semi-industrial units in rural areas depends on many factors, including the regularisation of the coarse grain market and the relative prices of imported cereals. Many semi-industrial units are hampered by the lack of a regular supply of sufficient quantities of millet and sorghum which are clean and of homogenous quality.

Industrial milling

Medium- and large-scale industrial milling of maize is common in Eastern and Southern Africa. In the medium-scale mills, simple roller mills with intermediary rotative separation systems are used. In large-scale mills, after pre-breaking and de-germing, the grain is milled in roller mills in a sequence of repetitive milling and sifting. In this way various types of grits and flour are produced.

Studies have shown that these mills are not always the most appropriate choice in terms of employment generation and the effective utilisation of capital and revenues. These studies include those conducted in Kenya by Stewart (1978) and Uhlig and Bhat (1979), and in Tanzania by Bagachwa (1992). With market liberalisation, it is possible that small-scale hammer mills may become more important in the maize and maize flour marketing systems. This was indicated in the Tanzania study and in a more recent study in Zimbabwe (Chisvo, 1995), where small-scale mills carry out a large part of the cereal processing, benefiting both the consumer and the small-scale producer.

For sorghum and millet, there is no large-scale milling on a commercial basis because the appropriate technology has not been developed. Trials using a semi-wet milling technology

have demonstrated that this technology is feasible (Cecil, 1987, 1989). It has not been adopted, however, mainly because it requires putting large amounts of water (about 20%) in the grain in order to obtain satisfactory hull separation in sorghum, and this requirement is viewed with suspicion by those in the conventional large-scale roller milling industry. Tests are being conducted by the NRI which involve the use of only 2–3% water in roller mills (L. Hammond, pers. comm.). The aim of these tests is to develop a technology that will handle sorghum varieties that are too soft for the PRL dehuller.

Dehulling and milling rice

With the development of large-scale rice irrigation schemes in Africa, large- and medium-scale mills were established, often by rice development authorities or marketing boards. Evaluations of available rice processing technologies were conducted in various countries in the 1970s, and it was found that large disc mills resulted in significant losses and were uneconomic. Large rubber roller mills could be justified only if they operated at full capacity and achieved high recovery rates. As this would be difficult to achieve, it was considered that the best options for rural areas, in terms of income and employment, were hand processing and small rubber roller mills (Spencer *et al.*, 1976).

In the past decade, decorticating and polishing by public sector large- and medium-scale mills have been taken over by private enterprises. In Mali, small Engelberg dehullers have taken over rice processing from the large industrial mills (Wanders, 1996). In Senegal and some other countries, large and small units still operate in the same market, with the small dehullers processing more than half of the rice crop. Most of the small units are Engelberg models with a capacity of 150–450 kg/h and a milled rice recovery of 55–65%, with a high percentage of broken rice. They are often owned and operated by groups of village men and women, as well as by traders and private entrepreneurs. The dehullers handle small and large batches from individual clients for household consumption and trade. At this level, polishing is done by increasing the residence time of the rice in the machine rather than by putting it through separate polishing equipment. This means that the hulls and bran are mixed, and the by-product is therefore unsuitable as animal feed. Sifting equipment is rare as villagers tend to prefer to sift the rice manually. Generally, village-level dehullers in Africa are of the Engelberg type. Rubber rollers are less popular in Africa than in Asia. In those that do exist the wear and tear of the rollers seems much higher than in Asia, even when milling the same rice variety. Research is being conducted to identify the factors (such as percentage of silica in the hulls) which might account for this wear and tear.

Semi-industrial mills ("minimills") with a capacity of 0.5–1.5 tons/h have been introduced more recently. These mills are proving to be very popular in Senegal with private traders and some village groups. Prior to their introduction, the Société d'aménagement et d'exploitation des terres du delta (SAED) bought rice and processed it in industrial mills, the profitability of this enterprise stemming mainly from the subsidies for milled rice. Since SAED's withdrawal

from rice processing activities, about 20 minimills have been installed in the country. The equipment is imported from Asia (China, Korea and Japan) and from Europe (France and Italy). CIRAD has developed a minimill in cooperation with a French manufacturer, Gauthier. Known as the Compact Rice Milling Unit, it consists of a rotating pre-cleaner, a dehuller/polisher and a rotating sieve for separating whole and broken rice. One of these mills has been established in Madagascar (Cruz and Havard, 1994).

There are various technical, training and management problems associated with minimills, particularly those operated by village groups (Touré, 1993). They are not as solid as the Engelberg dehullers and thus require far more maintenance. Most problems tend to occur as a result of wear and tear of the elevators, the rubber rollers and parts of the polishers (Tandia and Havard, 1992). Some problems are similar to those occurring in semi-industrial coarse grain mills. To make optimal use of minimills requires a good supply of rice, a large working capital and, when supplying urban markets, a high standard of polishing and grading.

Another important operation in rice processing is parboiling, which is carried out before milling. This process stimulates the transfer of nutrients from the aleuron layer to the inner rice kernel. The process has an effect on the taste of rice that is preferred in some regions, and nutrients that would otherwise be lost during milling are retained in the kernel. The NRI Agro-processing Group concluded during studies of rice processing that there was a need to improve parboiling efficiency. The institute has developed a prototype vacuum vessel to improve the parboiling process by reducing soaking time and water consumption. This technology is currently being tested (D. Jones, pers. comm.).

Secondary processing

Since the introduction of mechanised food processing technologies in Africa, relatively few enterprises based on cereal processing other than service milling and large-scale commercial milling have been established. The trade in cereal-based consumer products is based mainly on household-level production by women, who also produce for the market. There are few examples of women investing in processing equipment to reduce their workload and/or improve their business. This has occurred to some extent for processing cassava to make *gari*, but such investments in cereal processing equipment are rare. Some mechanised enterprises exist for making bread, pasta products and couscous, but these industries tend to use imported wheat. Cases where mechanisation has been successfully introduced to make couscous from maize or millet or to make biscuits and weaning foods from composite flours are relatively rare. This does not mean that there is no potential for development in this sector. What is needed is a market-oriented approach, something which has been lacking in many research and development programmes.

An important factor in technology development in the 1970s and 1980s was the policy of stimulating demand for locally grown cereals as substitutes for imported wheat and rice. With increased urbanisation and changing food consumption patterns, the demand for wheat

and rice had grown. Many projects were initiated to produce wheat substitutes, for use in bread and pasta, and rice-like products. These projects succeeded in only a few cases on a small scale for certain products such as maize grits (Faure, 1991) and pearled sorghum (Nyambati and James, 1987) or when wheat imports had been severely restricted (Baidu-Forson and Ajayi, 1995). Part of the problem was product image; maize grits were marketed as rice substitutes under labels such as "corn rice" or, worse, "poor man's rice", whereas they should have been marketed as an alternative maize product. And although it is certainly possible to produce good-quality bread using a fairly high percentage of non-wheat flour, most commercial mill and bakery owners consider that consumers prefer white wheat bread. In addition, the price and availability of good-quality, non-wheat local cereals is such that they are not attractive to the flour milling industry. A lesson that can be drawn is that although product diversification is technically possible and often of interest to businessmen and women, it needs to be based on consumer-related research.

The need for such research has been recognised by the CIRAD-SAR project known as Projet AVAL, established to conduct food processing studies relating to consumer preferences, local practices and the use of indigenous knowledge, and to encourage the exchange of information among those involved in small-scale food production and marketing. At a seminar in Benin in 1994 on village-level maize processing in West Africa, it was revealed that there are about 40 different maize-based food products in Benin (Figure 1) but relatively few in Burkina Faso (Nago *et al.*, 1995). The commercially available products fell into two categories: semi-finished products ("ready to cook") and cooked products ("ready to eat"). Through Projet AVAL, exchange visits were organised to enable small restaurant owners and market women from Burkina Faso and Benin to learn from each other's knowledge and experiences. The role that product orientation, needs assessment and response to user needs have to play in technology development activities is also recognised by other research and development organisations such as IDRC, KIT and NRI.

As indicated earlier, enterprise development in the secondary processing sector has not been very successful in Africa, partly because of the technology-driven approach. Some examples of the development of secondary processing enterprises are outlined here, however, to illustrate what is happening in this sector and to show its potential. It needs to be stressed that enterprise and product development will not occur unless there is more emphasis on a market-oriented approach.

Weaning foods

A process for producing weaning foods, based on roasting and milling locally grown crops, was adopted in the 1970s in Benin and by projects in other African countries. The raw materials include maize, sorghum, millet, cowpeas, groundnuts and/or soyabeans, selected according to availability and local taste. They are pre-cleaned and, if necessary, dehulled and then individually roasted, mixed according to given proportions and milled as a mixture. The flour is put into double-lined plastic bags and labelled. The roasting and packaging guarantee

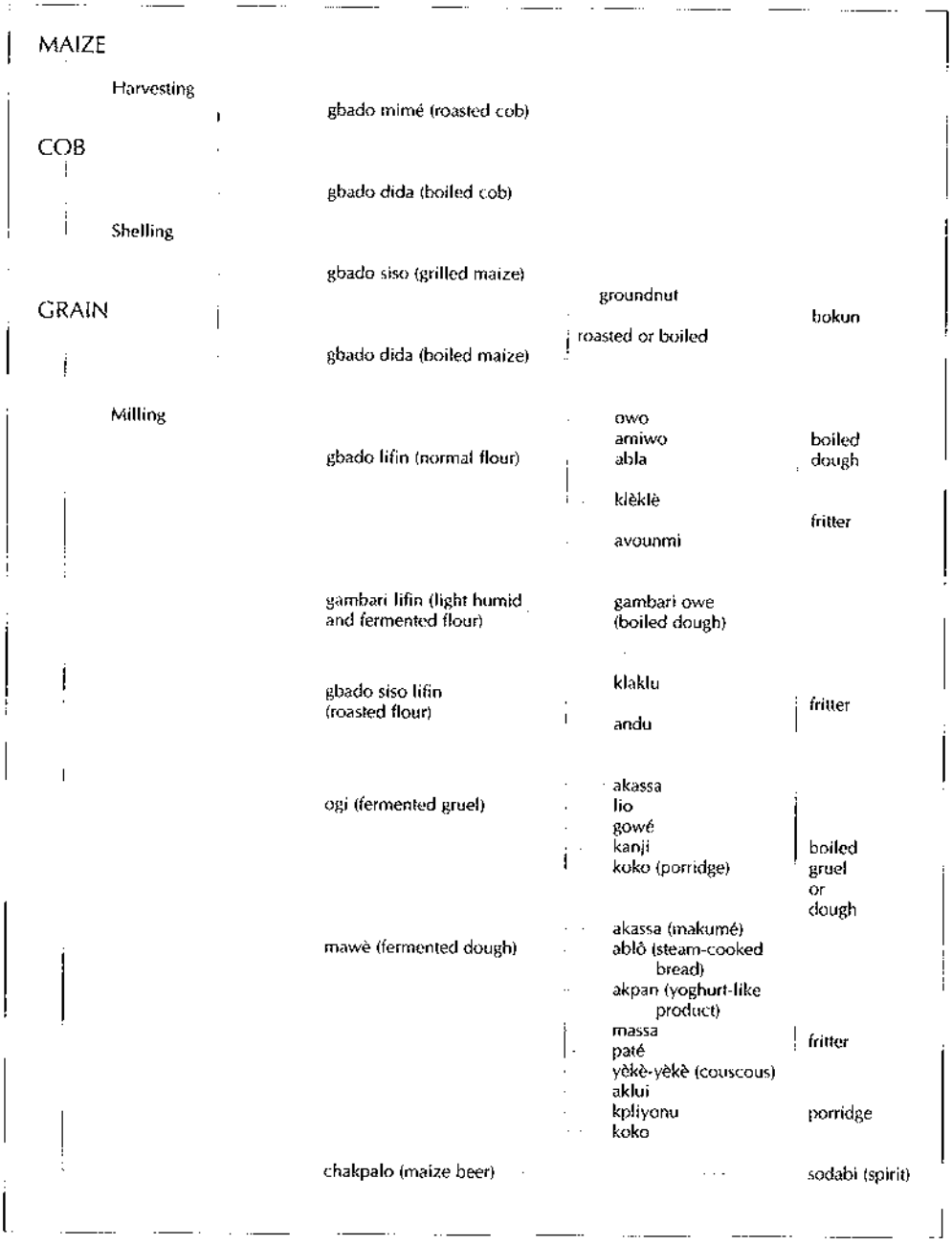

FIGURE 1 Known maize food products in Benin
Source: Nago *et al.* 1995

product quality for at least 3 months. This process produces a highly nutritious weaning food costing a third of the price of imported cereal-based baby foods (KIT, 1987). Using the same process, products for other target groups such as nursing mothers or school children can be produced. The selection of a simple and safe process and the use of locally available raw materials are ingredients for a successful approach. The products will not necessarily be successful, however, unless backed by a sound marketing approach (Meerendonk and Würdemann, 1996).

Small weaning food enterprises based on this "KIT-type" process are now operating in Benin, Burundi, Ghana, Malawi and Niger. Similar projects with private or cooperatively run enterprises have been set up with technical assistance from other sources (Misola, 1989; Treillon, 1992). In addition, many groups have been established based on manual pre-cleaning, roasting and mixing, with the milling done by the local cereal mill. This approach suits village-level operations where the women run the enterprise as a cooperative, selling most of the flour but keeping some back for household consumption. Few of these enterprises are up-to-date on recently developed food fermentation methods for the production of safe weaning foods. The advantage of these methods is that acid fermentation helps to stabilise the product and prevents hygiene problems when adding water. It also makes drying of the product directly after processing less necessary, thereby saving on costs.

Couscous

The second-phase prototype of a machine for making rolled couscous developed by CIRAD is being tested. The first prototype was tested at the time of this study and adapted for coarse grain flours at the University of Benin, but a high degree of recycling was required in order to obtain acceptable product quality. This should be improved in the second prototype (Faure, 1995; J. Faure, pers. comm.).

Pasta

Tests on pasta production, based on two parts maize and one part wheat, are being conducted by CIRAD and the Institut de technologie alimentaire (ITA), as well as by the food industry in Senegal and Cameroon. The tests are aimed at excluding the need to pre-cook the maize as a substitute for the lack of gluten and finding the most effective drying process (Schmidt-Leplaideur, 1984; Faure 1992; J. Faure, pers. comm.).

Fermented products

The production process for many intermediate food products made from cereals includes fermentation. Over the past 15 years much work has been done on analysing and improving

traditional fermentation processes (e.g., Reilly, 1995; Nago *et al.*, 1995; WHO, 1996). This work has included:

- Analysis of the microbiological processes, isolation of micro-organisms and development of appropriate starter cultures to improve and control product quality and reduce processing time by rapidly increasing the acidity of the product;

- Analysis of unit operations in the production process with a view to optimising the process, reducing the amount of difficult work required and improving efficiency and profitability;

- Analysis of product safety with regard to human health, and a search for process improvements to improve safety and nutritional quality;

- Development of more stabilised products through pre-cooking and dehydration of previously fermented products;

- Socio-cultural assessment of suitability and feasibility of new or improved fermentation technologies before introducing them.

Examples of fermented products being studied are *kenkey* and *mawè*, both derived from maize, as well as products from other cereals or from cereal/legume mixtures. *Mawè* is an intermediate product from maize that can be used as an ingredient in various food preparations. With increased urbanisation, the market for this kind of convenience food may increase, even in countries where it is not currently known. Legume-supplemented cereal foods have been evaluated and the prospects for using such foods for infants look promising (Nche *et al.*, 1994).

Chapter 3

DEVELOPMENTS IN ROOT AND TUBER CROP STORAGE AND PROCESSING

The most important root and tuber crops in Africa are cassava, potato, sweet potato and yam. The perishability of the harvested products is such that a lot more caution is needed to prevent loss during storage and transport than is the case with cereals. Thus the purpose of processing is for both consumption and preservation.

This chapter looks first at root and tuber crops within the context of the food chain. The discussion then focuses on storage practices and developments. The bulk of the chapter deals with processing operations, taking each crop in turn and providing an overview of developments and of areas where further research and development is needed. Valuable publications for additional and more specific information on processing and marketing are FAO (1988, 1989c, 1989d), UNIFEM (1989), Asiedu (1991), Bencini and Walston (1991), Scott *et al.* (1992a, 1992b), Ofori and Hahn (1994) and Wheatley *et al.* (1995).

The food chain

Root and tuber crops play an important role in the agro-economics of most African countries, contributing significantly to basic food requirements in urban and rural areas as well as having some non-food uses. In general, however, the marketing of these crops is poorly organised (Griffon, 1995) and they are not receiving much attention from research and development bodies. They are grown mainly in a subsistence context, resulting in an inadequate supply to markets. Inconsistency in quality appears to be a major factor constraining expansion of the sector. Other constraints with regard to production include high labour requirements, low genetic potential in terms of yield, and pest and disease problems. The main crop utilisation constraints are poor storability and the lack of appropriate processed products.

The main delivery constraints for each of the major crops are (Onwueme, 1994):

Cassava	Inadequate availability of suitable planting material, inability of fresh roots to be stored for long periods, and the need for detoxification
Potato	Ideally, temperate conditions are required (but efforts are being made to produce cultivars that will yield well under tropical lowland conditions)

Sweet potato	Inadequate provision and availability of planting material, fresh tubers store poorly, there are few processing technologies, sweetness makes some varieties unpopular, the ripe tuber is attacked by the sweet potato weevil, and more work is needed on developing non-sweet, weevil-resistant varieties
Yam	Labour requirements for crop production are high, yam has a low multiplication rate, spoilage is common during storage, and there is a need for cheap processed forms to avoid having to store large quantities of fresh roots

Research and development efforts on root and tuber crops have tended to be technology driven, but more interest is now being shown in market- and consumer-oriented approaches. To improve the status of these crops in the market, research is needed in several areas (Scott *et al.*, 1992a, 1992b; Griffon, 1995):

- *To respond better to the increasing demand for root and tuber crops.* Demographic changes (increased urbanisation, as well as increased population density in rural areas) indicate a need for higher yielding varieties and a reduction in post-harvest losses;

- *To adapt production systems to market requirements.* There is considerable potential for increasing production for the market. Until recently only about 20% of the production of most root and tuber crops was marketed (FAO, 1989b). Using current knowledge to increase production and overcome transport, storage, preservation and processing constraints, information on market needs should become available;

- *To expand the market for existing products.* With the increasing demand for root and tuber products, the market could possibly be expanded. Products known in one area might prove popular in other areas. For urban consumers, for example, intermediary and convenience products such as *gari* (fermented, roasted cassava flour) and *chikwangue* (a pre-gelatinised cassava paste) (Trèche and Muchnik, 1993) could become more important;

- *To identify new good-quality products.* An increase in purchasing power has led to a gradual increase in the market for food that has been processed. Another effect of the observed increase in income is the increase in meat consumption and therefore in animal feed consumption.

In response to growing interest among farmers, traders, researchers and policy-makers in root and tuber crops, three international institutes – CIP, IITA and the Centro Internacional de Agricultura Tropical (CIAT) – convened a workshop in 1991 on product development for root and tuber processing, marketing and utilisation in Africa. The workshop produced valuable information (Scott *et al.*, 1992b), and Wheatley *et al.* (1995) produced a useful manual on product development that includes case studies.

Wheatley and Scott (1992) describe a clear methodology for the identification of product opportunities. A checklist for screening possible products has been developed by CIAT and IITA as part of a training manual on product development for root and tuber crops (Figure 2). Using this list, product ideas can be developed and tested among consumers by asking them to comment on the idea and how they would use the product. Further market and technological research will be required to define the product characteristics, the processing required and the marketing strategy to be used.

As noted earlier, the market for processed products is expanding. Research responding to this trend needs to be based on the recognition that root and tuber crop processing in Africa is dominated by women, working alone or in groups. There is little interest in this activity from commercial industrial enterprises because available large-scale processing techniques cannot yet guarantee quality products that will find broad acceptance among consumers. Studies on improving various stages of the food chain should therefore work closely with all actors involved, beginning with consumers. To date, most research has been rather descriptive, but CIRAD-SAR is now conducting studies on the different stages in the marketing system. A study has been done, for example, on cassava products in the Congo. Broader marketing studies on cassava (Agbor-Egbe, 1995) cover:

- Trade and processing;
- Functioning of small processing enterprises;
- Enterprise organisation, functioning and networking;
- Consumer preferences and, in urban areas, product acceptability;
- Relative importance of various cassava products.

In 1992 the NRI initiated a project on the "Transfer of Needs Assessment Methodologies and Post-Harvest Technologies for Non-Grain Starch Staple Food Crops" in sub-Saharan Africa (A. Westby, pers. comm.). Field studies have been undertaken in Ghana, Tanzania, Uganda and Zimbabwe on cassava, yam, plantain, sweet potato and cocoyam, and include analyses of marketing channels. The methodology used is based on the rapid rural appraisal (RRA) technique. One aspect of the project involves the dissemination of information to key persons and organisations. Four workshops have been organised and a working manual on needs assessment produced (Kleih and Digges, 1995). A manual on quality assessment as a means of controlling post-harvest losses will also be published. Technology transfer activities based on the needs assessment studies have been initiated. Although this work has been carried out in Ghana and Tanzania, the results could be applied elsewhere. These results focus on:

- Use of cassava in livestock rations (Ghana);
- Market expansion for cassava through increased use of flours and starches (Ghana);
- Reduction of losses in fresh cassava roots during transport from rural to urban areas (Dar es Salaam, Tanzania);
- Improvement of quality and utilisation of processed cassava products (Tanzania);
- Transfer of improved cassava processing techniques at household level (Tanzania).

DEMAND
- Define target market (city, region, etc.)
- How many consumers (total, and percentage who could purchase?
- How much product per person per year?
- Is purchasing power increasing or not?
- Are consumption/food purchase habits changing?
- Does product fit these changes?
- If product is novel, will acceptance be good?
- If product is competing against others, will price and quality be better than competitors?
- For industrial markets: What is the volume of purchases and the price of competing raw materials by industries concerned?

RAW MATERIAL SUPPLY
- Volume of production in target region
- Demand in other markets for this production
- Seasonality of production and demand in other markets
- Price fluctuations/cycles
- Characteristics of both traditional and new varieties (growth cycles, quality, yield)
- Potential for and constraints to increasing production (diseases, erosion, drought, etc.)

PHYSICAL FACTORS
(determine harvest times and feasibility of natural drying systems)
- Rainfall (dry and wet seasons)
- Does dry season coincide with harvest time?
- Temperature
- Relative humidity
- Is there ready access to clean water (for starch extraction especially)?

ORGANISATIONAL ASPECTS
- Are farmers market- or subsistence-oriented?
- Are farmers willing to experiment?
- Has there been a positive experience with cooperatives?
- Is institutional support available for cooperatives/ small businesses?
- Is credit available?
- Are capital requirements manageable?
- Is a separate distribution entity needed? Is technical and financial support available for this?
- Will many institutions be involved? Is inter-institutional coordination satisfactory?

EXISTENCE OF SIMILAR ACTIVITIES
- Is small farmer processing novel or a continuation of existing practices?
- What are the strengths and weaknesses of existing operations?
- How can weaknesses be corrected?
- Are there any existing facilities that can be utilised to reduce capital outlay?

CONSUMER ACCEPTANCE
- Is this crop accepted in the diet (fresh, processed)?
- Is image good or not?
- Is this product being made already? If not, why not?
- If an existing product, what improvements can be made?
- If a novel product, is this crop accepted in other foods or is it a food accepted with other ingredients?

CAPITAL REQUIREMENTS
- Amount, conditions of loan (interest rate, period of grace, etc.)
- Requirements for collateral (land holdings, etc.)
- Standard banking arrangement or special loan scheme for small businesses/cooperatives.

LABOUR
- Costs
- Availability (seasonality)
- Educational level
- Gender issues: replacing manual operations by machinery often reduces the women's role and can have negative social consequences

TECHNOLOGY
- Is it already developed, or is further research required? If so, how much and what are the chances of success?
- Imported or local? If imported, are spares, etc. available?
- Can it be managed by farmer group if necessary?
- What training will be required (process operation, business, marketing, etc.)? Who can provide and finance training activities?
- Can local labour and materials be used in construction?

BENEFITS
- How well will the product fit project objectives?
- Who will benefit and by how much?
- What is the risk of failure? Who suffers if project fails?
- How much: i.e. economic feasibility?

FIGURE 2 Checklist for final screening of products
Source: Wheatley and Scott, 1992

Storage practices

Cassava

As a result of the NRI needs assessment project, an improved storage method for fresh cassava has been developed and transferred to farmers, traders, market women and restaurant owners. Good roots can be preserved for 7–10 days by separating them from damaged roots, dipping them in water immediately after harvest and storing them in sacks, wrapped in polyethylene to retain the heat, placed above ground level and protected from direct sunlight (Bancroft and Crentsil, 1995). In 1996 the NRI produced, in cooperation with the Ghana Ministry of Agriculture, a video film entitled "Always fresh cassava" demonstrating this technology (NRI, 1996). The use of this technology significantly reduces losses. If a fungicide (thiobendazole) is added, storage life can be increased to 2–3 weeks, although 1 week is generally sufficient according to the operators in the cassava marketing chain in Ghana.

Potato

Potatoes have a long dormancy period and are best stored at about 6°C and 92–95% RH. Ideal conditions for long-term potato storage in most places in Africa, however, are seldom attained, and potatoes and seed potatoes intended for commercial purposes should therefore be preserved in storage facilities with forced ventilation and possibly also chilling equipment. Feasibility studies should be carried out prior to constructing such facilities. Optimising the use of these storage facilities by storing fruit and/or vegetables during certain periods of the year may be the only way to manage these installations profitably.

Simpler means of storing potatoes, such as underground or in well-ventilated sheds, protect them only for relatively short periods in hot regions; storage over a longer period is possible only in colder regions (Geertsema, 1990). Hunt (1991) notes that storage using natural convective ventilation is effective during dormancy, giving an extra storage period of about 1 month and keeping losses below 10% of the original weight. Dormancy can be prolonged for about 2 months if the storage temperature is kept below 20°C using propham or clorpropham. If the temperature is kept below 15°C, dormancy can last for up to 5 months.

For seed potatoes, an important improved storage technology is the diffused light storage (DLS) method. The use of this technology in Sri Lanka has resulted in less dependency on foreign seed imports, a reduction in storage losses, an increase in yields, and changes in cropping patterns; it has also added prestige to agricultural research and extension programmes (Rhoades, 1986). In a study in northern Cameroon, it was found that seed tubers stayed in excellent condition in rustic diffused-light stores for up to 90 days (Ntonifor *et al.*, 1991).

Sweet potato

Sweet potato has long been grown as a subsistence crop and in many developing countries it is a famine prevention crop. Studies on its nutritional properties, however, have only recently started, and little is known about consumer demand. Only recently, for example, has it become known that demand for sweet potato has been rising in Tanzania and Uganda. In most households both the tubers and the leaves are consumed.

The market for sweet potato has high potential for commercial expansion but there are several constraints that need to be addressed first; these relate to production levels, transport, storage and market facilities, and the lack of diversification in products made from sweet potato. It has been suggested that weekly broadcasts of sweet potato prices would help to make growers aware of market opportunities in urban areas (Scott *et al.*, 1992b).

Using a participatory rural appraisal methodology, the NRI has conducted a survey on sweet potato storage practices in Uganda, where sweet potato has now largely replaced cassava because of losses as a result of cassava mosaic virus. Unlike cassava, however, sweet potato cannot be stored in the field because of weevil attacks. Using current practices, sweet potato can be stored for about 1 week after harvest. Improved storage methods have been developed, and prolonged storage, for up to 5 months during the dry season, is now possible (NRI/NARO, n.d.).

Yam

Few technologies have been developed for improved yam storage. A study in Côte d'Ivoire evaluated storage losses in relation to market price fluctuations (Doumbia, 1990). It showed that losses over a season may reach 40–50%, and that higher prices at the end of the season did not compensate for such losses. Germination may be delayed by using gamma-irradiation, but this is profitable only when treating large quantities. Transport problems make this generally impractical.

The greatest cause of storage loss is the deterioration caused by moulds and bacteria. This can be reduced by preventing damage during harvest and transport. When tubers are damaged, the injured areas should be cut out as they are a source of infection. The tubers should then be placed under jute sacks or under a thin layer of soil. Depending on the type of yam and the extent of damage, the conditions under which the tubers should be kept vary from 26°C and 66% RH to 40°C and 98% RH. The possibility of influencing dormancy is limited because below 15°C the tuber tissue is destroyed by chilling. The best results are obtained at 16–17°C, when respiration losses are limited, but this is not practical at village level. Providing shade and ventilation and protecting the tubers against insects and mammals are important practical methods for safe storage. More detail on yam storage, including information on traditional yam barn improvements, is provided by Knoth (1993).

The Swiss research centre in Côte d'Ivoire has studied the use of a diboralic acid dip to prolong dormancy. The acid prevents sprouting but maintains the physiological state of the tubers. For some varieties this means that they remain bitter. The NRI is now conducting studies in Ghana on yam marketing and on changes to plant physiology that would improve consumer acceptability (R. Bancroft, pers. comm.).

Cassava processing

Cassava is one of the most important staple food crops in tropical Africa. It makes a significant contribution to food security because of its efficient food energy production, year-round availability and tolerance of conditions of extreme stress such as drought and poor soil (Hahn, 1989). The Collaborative Study of Cassava in Africa (COSCA), being coordinated by IITA and involving over 200 villages in six African countries, has shown that cassava production has increased in recent years (Nweke, 1994).

The perishability of the crop and its potential toxicity make processing crucial. Sweet roots can be eaten raw or after boiling but more elaborate processing is needed for bitter or toxic roots. Cassava originated in South America and spread over Africa and Asia, giving rise to a great number of processing techniques and products. Apart from the processing and use of cassava as a food in Africa (Figure 3), the crop can also be processed into chips for animal feed

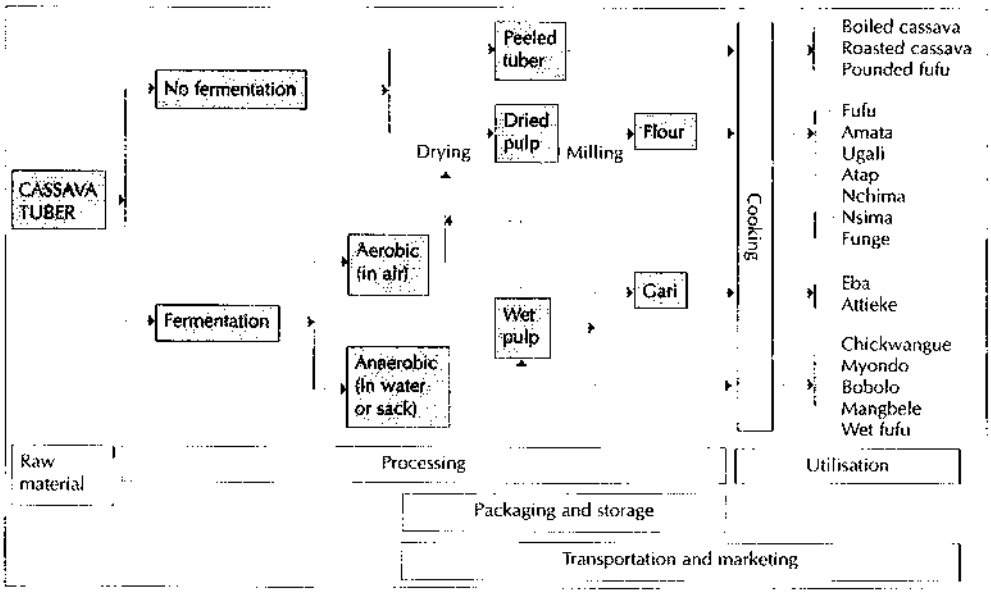

FIGURE 3 Summary of traditional cassava processing and utilisation in Africa
Source: Hahn, 1989

and into starch for many food and non-food uses. Through fermentation, it can be used for alcohol, yeast and protein, and as a waste material it can be processed to biogas.

An important objective of the COSCA study is to identify and analyse cassava processing practices in Africa (NRI, 1992). The NRI is responsible for this aspect of the study and a large volume of data is now being analysed. Important reasons for the development of cassava processing technology include food safety, reducing the workload and creating opportunities for income generation and enterprise development. Needs assessment is an essential element of such studies and the NRI is developing and transferring appropriate techniques (Kleih *et al.*, 1996).

In some cassava growing areas in Africa, cultivars with a medium to high cyanogene content are replacing sweet varieties because of their higher productivity. The consequent increased incidence of health problems attributable to cyanide exposure from insufficiently processed cassava emphasises the need for adequate detoxification methods. Essers (1995) studied various traditional processing technologies. Known methods of detoxification include:

- Soaking the roots for several days in water and then drying them or making them into a paste;
- Making *gari*, which involves peeling, grating, pressing/fermenting, sifting and roasting;
- Heap-fermentation (by moulds), followed by sun-drying;
- Direct drying of roots or chips;
- Grating and roasting/drying (*farinha de mandioca*).

Based on the work of Essers (1995) and others, projects are now being implemented to introduce relatively fast but safe methods for processing bitter cassava into various products, the most promising of which appear to be *gari*- and *farinha*-like products. These methods are being promoted in Mozambique and Uganda. "For women in Mozambique it was an eye-opener to see that after peeling, grating and sun-drying for a few hours the cassava could be boiled and eaten the same day" (A. Essers, pers. comm.).

The studies on improved cassava processing involve extensive work on biochemical and microbiological issues (Westby, 1994; Essers, 1995) and on appropriate approaches to technology selection and dissemination (Bainbridge *et al.*, 1994). The NRI, which introduced West African processing methods such as *gari* production into Tanzania, has trained extension officers to demonstrate good and bad processing methods. Much interest has been shown in *gari* but there are reservations about the amount of fuelwood needed and the suitability of grating technologies. Graters are being tested and introduced by some agencies, including the German development agency Gesellschaft für Technische Zusammenarbeit (GTZ).

Group dynamics are an important factor in technology dissemination. In Uganda a mutual support group rapidly adopted the *farinha de mandioca* technology because selling flour was

far more profitable than producing and selling chips from heap-fermented roots. Another factor in the successful adoption of this technology was that the group consisted of shop and restaurant owners and retailers who had the means to invest in it. By contrast, village women in Uganda showed no interest in adopting this technology (A. Hall, pers. comm.)

Although constraints are often inherent in the adoption of technologies from elsewhere, there is enormous potential for the South-South transfer of technology. For example, the fermented cassava dough or paste known as *chikwangue*, which is currently produced in rural areas in Congo and accounts for about 30% of the cassava products marketed in Brazzaville, may be of interest to consumers in other regions or countries and could stimulate the development of artisanal processing enterprises (J. Muchnik, pers. comm.). Technologies from South America, such as sour starch for bread manufacture and biodegradable packaging, may be of interest in African countries (N. Zakhia, pers. comm.; information leaflets produced by CIRAD; Zakhia, 1995). Also of potential interest to Africa are the experiences in South America in developing and disseminating cassava chipping and drying technologies for animal feed (Henry and Best, 1994). Careful consumer and market research will be necessary, however, before introducing such technologies into Africa.

The literature on food safety and processing technology for cassava is extensive. Two publications worth specific mention are the proceedings of a workshop on cassava safety held in Nigeria (Bokanga *et al.*, 1994) and the proceedings of an International Society for Tropical Root Crops (ISTRC) symposium held in Ghana, 1991 (Ofori and Hahn, 1994). Other useful publications are listed in the opening paragraphs of this chapter.

Gari production

In some cassava growing areas most of the women produce *gari* for the market. In Benin, Atidégla (1994) has observed that profits depend on production capacity and access to capital, and are not influenced by vertical integration arrangements (using cassava from own fields). In other words, the best results are obtained when the working capital is large enough and there are adequate storage facilities. Individual private enterprises tend to produce greater profits than group or cooperatively run enterprises, but only a quarter of all enterprises have reasonable profits.

The most successful technologies in mechanised *gari* production in West Africa are the mechanical grater and press (Nweke, 1994). Mechanising grating and pressing reduces workload and processing time significantly. Igbeka *et al.* (1992) suggest that the best machines are the Nigerian drum grater and the Ghanaian circular plate grater. The investment costs would be suitable for groups but too high for individual processors. Groups operating these technologies successfully in Ghana are mentioned by Kreamer (1986) and Nyarko-Fofie (1989). In southern Benin, Beck (1995) notes that there are over 30 groups or associations operating as *gari* production enterprises.

Most women producing *gari* on an individual basis now use commercial graters in service mills; if they lack access to this facility, they grate by hand. Peeling is done mainly by hand; mechanising this step often requires large quantities of water and has not proved to be efficient. Attempts have also been made to mechanise roasting, but it remains difficult to obtain a good-quality product using rotative or pedal-operated roasters. Manual roasting still seems to produce the product preferred by consumers, and there is still room for improvement in manual frying (Igbeka, 1995). The oven is designed so as to reduce the heat to which women are exposed, allowing them to adopt a sitting posture which improves efficiency.

An important aspect of *gari* processing is that when it becomes mechanised, men often become more interested in the activity and take over some of the work. This does not mean that the technology should not be introduced, but there is much to be said for providing it directly to women (Koller, 1986). There are groups of women making profitable use of mechanised graters, and other groups and individual processors using service graters. For some, however, it may be more attractive to have access to locally manufactured low-cost, low-energy graters which can be operated easily by women (Hahn, 1989).

The large-scale *gari* processing enterprises introduced in the 1970s proved to be less economically viable than small and medium-scale enterprises (Ngoddy, 1980). There is no reason why this would still not be the case, but because of the large amount of processing equipment available now (Chuzel *et al.*, 1986; Igbeka *et al.*, 1992; Igbeka, 1995; Jeon and Halos, 1992; Sanni, 1995) it might be worth comparing currently available options. The overview by Igbeka *et al.* (1992) is valuable but it is not easy for rural development agencies to gain access to such information and advise villagers of the most appropriate options. Atidégla (1994) has shown that small and medium *gari* production enterprises are best assisted by:

- A technical information network linked with training and research centres;
- Credit facilities to enable them to expand the volume of the business;
- Storage facilities which enable them to be less dependent on traders in terms of prices.

Starch production

There are few starch production enterprises in Africa. Most starches are imported and have been produced according certain specifications, depending on their application. In some cases it will not be easy to substitute local starch for imported starch. Some research institutions, however, are conducting studies which may lead to starch production becoming more widespread in Africa.

As noted earlier, CIRAD is working on adapting technologies developed in South America for the production of fresh and sour starches. Findings from the NRI studies on improving small-scale starch production in Asia could be important for Africa. In Tamil Nadu, for example, where the main use of cassava for income generation is the production of starch and

sago (used here as a sort of couscous made from cassava starch), the NRI's work revealed two production constraints: pollution due to effluent disposal and a 20% loss during wet starch storage. Further study showed that the use of citric acid could eradicate this loss, and water utilisation could be reduced by 50% by applying hydrocyclones. The application of hydrocyclones has the added advantage of producing better quality starch, but the feasibility of investing in hydrocyclones depends on whether, under pollution control legislation, the discharge of effluents from starch production is taxed. Both techniques are now being tested in a study on local starch production in Ghana and could be important elsewhere in Africa.

Potato processing

An important aspect of processing is that it is often intended to prolong the period during which a product can be preserved under ambient conditions. The most appropriate products in this respect are dehydrated potato products such as starch and flakes. The processing will be successful, however, only if the product is acceptable to consumers in terms of quality and price.

To produce 1 kg of dehydrated potatoes, about 5 kg of fresh potatoes are needed. Potato processing at industrial level will therefore be viable only when the installed equipment can also be used for the processing of other raw materials. Sun-drying has lower investment costs and could therefore be more economic. In order to preserve natural colour, flavour and nutrients during drying it is necessary to boil the potatoes before cutting and drying the flakes. In a project in Kenya, however, fresh potatoes are sliced, washed and given a sulphite treatment before being dried. After sun-drying, the chips are milled and the flour used in a composite flour mix for bread.

When produced in solar driers, potato flour may be cheaper than flour from local cereals and could partly replace flour from imported wheat if current price supports for these imports are modified (Kabira, 1992). Until such modifications are made, however, making composite flour mixes for bread will be a problem. Another problem is that sun-drying should be accompanied by artificial drying, but this would make the flour more expensive. When the potatoes are dried to produce flour for potato puree, pre-boiling at 70°C is necessary to improve the texture of the final product. The process for producing potato starch is similar to that for cassava and other root or tuber crops (washing, pulping, separating fibre, washing, sedimentation, drying and sifting). More detail on these processes is provided by Geertsema (1990, 1994).

Scott *et al.* (1992c) describe other dehydration processes, including traditional potato processing in the highlands of South America. They analyse attempts by various institutions over the past 15 years to improve simple potato processing in Peru (Figure 4). Apart from these dehydrated products, potatoes can be processed to make snack foods such as fresh and dried chips. These processes can be done on a very small scale.

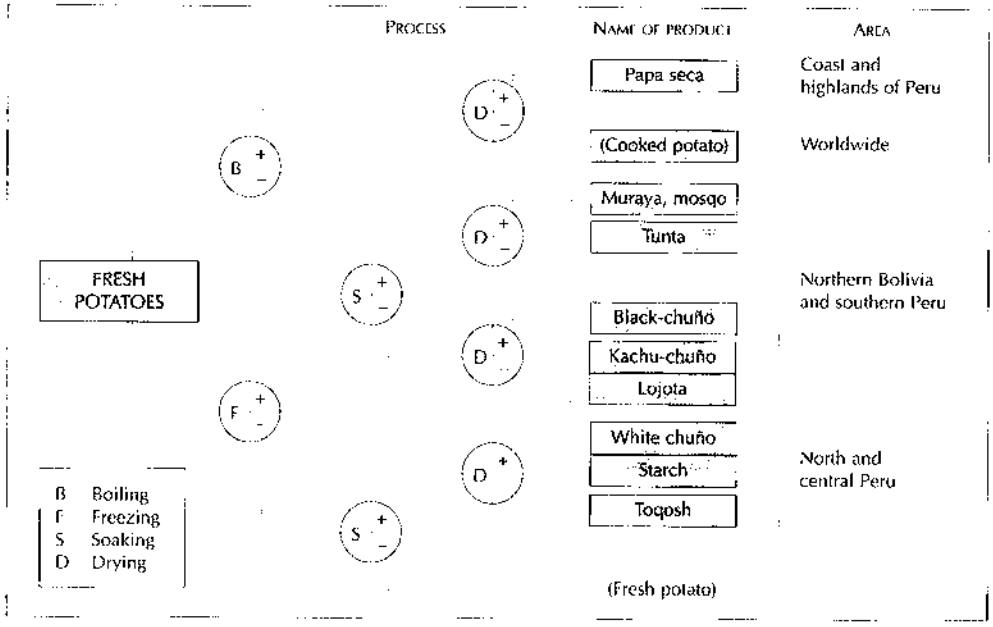

FIGURE 4 Potato processing in the highlands of Bolivia and Peru
Source: Yamamoto, 1988 in Scott *et al.*, 1992c

Scott *et al.* (1992c) also describe some examples of the development of dried potato products that are worth noting here. In response to growing interest in the commercial potential of traditional potato products, and the varying times required to make them, scientists at CIP began research on finding faster drying methods for *papa seca*. These improvements were intended to enable producers to increase and accelerate production, reduce production costs per kilogram and create a larger commercial outlet for the traditional processed product. This led to the development of the "black box", a solar cabinet drier. Further studies showed, however, that it was not the time and labour involved in drying that was seen as a constraint, but potato peeling. A large-scale production project failed because of the seasonality of the potato supply and price fluctuations, and because not enough attention had been paid to the need for product diversity if per capita consumption of potato products was to increase; consumers should be able to use potato products in a variety of ways in food preparation. Later in the project, various cereal-potato mixes were developed. Lessons in technology development and transfer arising from this and other experiences are discussed in Chapter 4.

Sweet potato processing

Sweet potatoes are usually prepared for consumption without special processing. The fresh tuber is boiled, baked, roasted or fried, and chips of fried sweet potatoes are sold as snacks

(FAO, 1989d). A major constraint to increasing the use of sweet potato is that the diversity of processed products is relatively under-developed in Africa, as noted earlier in the discussion on sweet potato storage.

In China, which accounts for 90% of global sweet potato production, there is great variety in the utilisation of sweet potato (Figure 5). Woolfe (1992a, 1992b) provides an overview of processes and products that could be introduced into Africa to help expand sweet potato

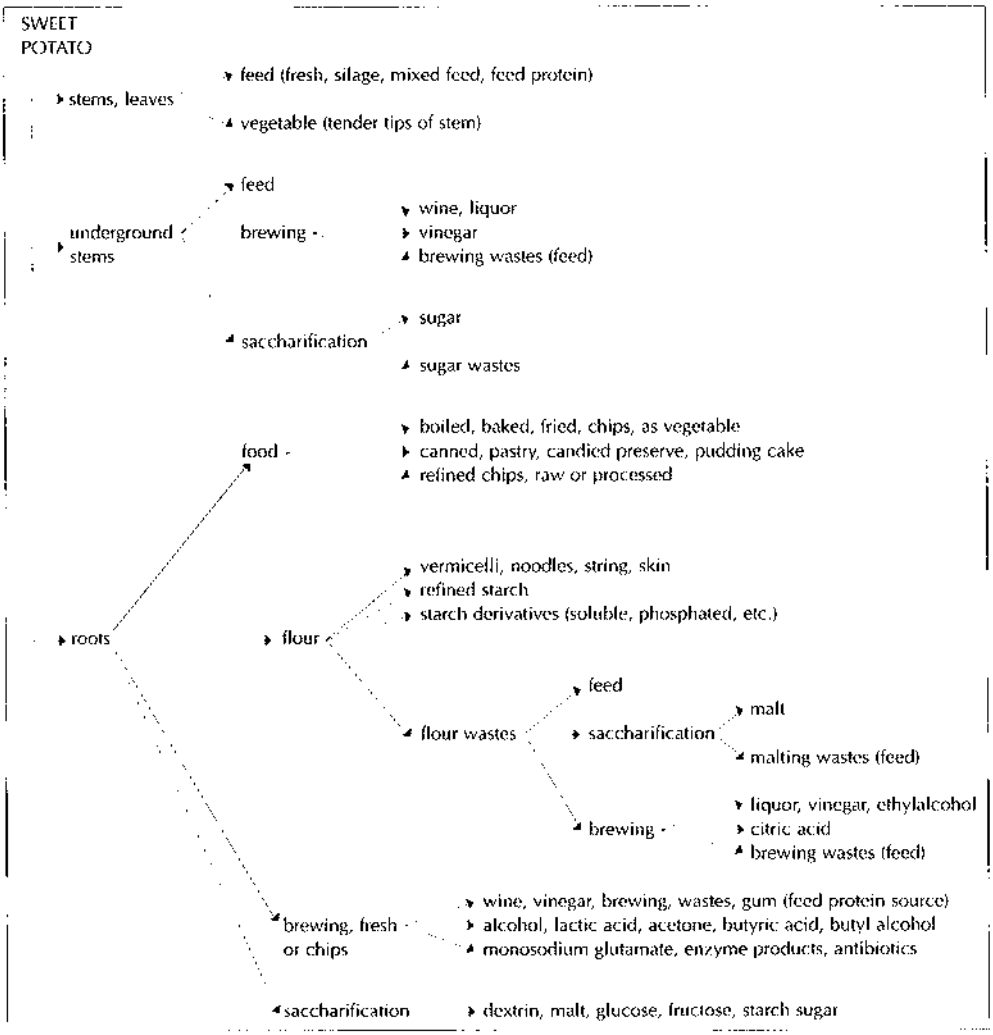

FIGURE 5 Utilisation of sweet potato in China
Source: Ge *et al.*, 1992

consumption. Most of these processes, however, involve the use of sweet potato as a component in other products and there are potential adoption problems similar to those for secondary cereal processing. One of the processes described concerns the use of grated raw sweet potato in bread as a wheat substitute (about 30%). Research on this process was conducted initially in Peru and subsequently in Burundi, Cameroon and Ghana. In Cameroon the process has been adopted by a suburban bakery and has proved successful, increasing the bakery's profits and providing consumers with competitively priced bread. Grated sweet potato could also be used in cake and pastry production. In other countries research has been done on incorporating sweet potato roots and leaves into pasta products, as is done in Europe with spinach. It is also feasible to make flour from parboiled, sliced and sun-dried sweet potato roots and incorporate it into bread and pasta products. In addition to these uses, sweet potato could be used in fruit products, ketchup sauces and non-alcoholic beverages.

Some of these product development activities are being supported by CIP (Scott *et al.*, 1992a, 1992b). Most of this work, however, is still at the laboratory or pilot stage. This is the case, for example, in Vietnam where work is being done on using sweet potato for the production of transparent noodles. The starch needed for this process can be produced at village level. Another example involves the transfer of technology to the private sector (farmers and private entrepreneurs) for using sweet potato in ketchup, jam, candy products and beverages. The market for such products in Africa, however, is not very developed. As noted by Wheatley and Scott (1992), efforts to improve and increase sweet potato processing in Africa will need to be preceded by careful identification of product opportunities. Work of this kind has been done, for instance, by the regional CIP in Nairobi with regard to sweet potato-based products in Uganda (Hagenimana and Owori, 1996).

Yam processing

Under a project entitled "Transformation de l'igname en cossettes" CIRAD is conducting a study of an indigenous yam processing technology. The technology is based on the traditional custom of boiling and sun-drying yam, using small tubers for preference or larger ones cut up. Farmers use certain herbs during boiling that have a mould-inhibiting effect. The study should demonstrate whether the technology is potentially of interest to a wider audience as a preservation method which could increase the market for yam (N. Bricas, pers. comm.).

Some attempts have been made during the past 20 years to produce good-quality yam flour, with varying degrees of success. In the Philippines, yam flour was produced for use in ice-cream manufacture; in Japan it was used with rice flour in pastry making; and in Barbados "instant yam" was processed to prepare puree. Problems included a bitter after-taste, discoloration and inadequate packaging. The most important issue is the need to incorporate a market-oriented approach into development work to ensure that the product satisfies consumer tastes and reflects market requirements. An example of this is the development

work in Côte d'Ivoire and Nigeria on *poundo yam* (Degras, 1993). Consisting of pre-cooked dried flakes, *poundo yam* is a convenience product for a traditional dish (pounded yam, *fufu* or *foutou*) that has been undergoing development for several years by the Cadbury company.

Tests on yam processing in Cameroon showed that it would be possible to produce flour at village level, but these studies were not accompanied by socio-economic or market analyses (Martin *et al.*, 1983). Small-scale yam flour production can be cost effective (Ezeh, 1992), but more research is needed on this.

Chapter 4

DEVELOPING SMALL-SCALE FOOD PROCESSING ENTERPRISES

Development efforts to promote the establishment of small-scale food processing enterprises need to be based on a sound understanding of current practices and technologies and their technical and socio-economic environment, as well as a clear vision of appropriate intervention strategies. Having discussed storage and processing within the context of the food chain and in terms of current and improved technologies, we now turn to the socio-cultural and economic factors involved in the selection and dissemination of technologies and in the development of small-scale food processing enterprises.

Technology selection and dissemination

Over the past few decades technological improvements in food processing have been stimulated by the availability of development assistance under various projects and programmes, and there has been increased interest in developing and disseminating appropriate technologies. Despite this interest, many projects have failed to achieve the expected results. Analyses of the reasons for this failure have been undertaken by many authors, including Stewart (1978), Bruinsma *et al.* (1983), Bruinsma and Nout (1991), Conroy *et al.* (1995) and Zoomers (1995). The main problems identified were that the technologies disseminated were often poorly adapted to the technical and socio-economic conditions of the end users and that not enough consideration had been given to the need for competitiveness in the market. Many examples of these limitations occur in reports on the introduction of technologies for processing cereals and root and tuber crops. Some examples are given here.

- *Adaptation to product requirements.* Abrasive disc mills used in the dehulling of sorghum and millet tend to cause problems with those varieties with hard testa (requiring harder carborundum stones), as well as with varieties with a softer inner kernel (causing spillage by breaking kernels) (Bassey and Schmidt, 1989). Regarding flour milling technology it is clear that for many traditional foods in West African countries a very fine flour is required. This cannot be produced by hammer mills, which are common in Eastern Africa, and disc mills are therefore more common in West Africa. There is also, however, the issue of food habits and taste. It is not easy, for example, to develop a maize flour with the right properties to prepare the traditional Malian dish known as *tô* using simple hammer mills (Boughton *et al.*, 1995).

- *Adaptation to the socio-cultural environment.* The introduction of pedal-operated cereal mills in Tanzania was not successful, as noted in Chapter 2. An analysis by CCT (1980) showed that one reason for this was that women in Tanzania seldom ride bicycles and were therefore unfamiliar with using pedals. Gender issues can often reduce the impact of a new technology, with the target group failing to benefit as intended. The provision of mechanical processing equipment intended to improve women's *gari* production enterprises often does not take into account the fact that men's participation in processing tends to increase when activities are mechanised (Ugwu and Ay, 1992). Similarly, the authors of a study on post-harvest technology in West Africa observed that: "Even when special interventions are geared towards women, the latter's access to technology with higher productivity remains very limited, compared to the access that men have to the technology" (Res and Niesten, 1995).

- *Adaptation to the socio-economic environment.* The sorghum dehulling technology widely adopted in Botswana has been less successful in other countries. Schmidt (1992) suggests that this might stem partly from incorrect or incomplete characterisation of problems faced by the target group, resulting in inappropriate technology intervention. Care must be taken to identify problems, not merely their symptoms, and to analyse these problems within their socio-economic context. There are many examples of technology interventions that were not the most appropriate solutions economically or in terms of employment generation. The large rice mills established in Mali have been taken over by small-scale and semi-industrial mills (Cruz and Havard, 1994; Wanders, 1996). Similarly, since market liberalisation, maize milling in Tanzania and Zimbabwe has proved more profitable when done in small mills (Bagachwa, 1992; Chisvo, 1995). Large-scale processing of cassava to make *gari* has also been shown to be less appropriate than operating at a semi-industrial level (Ngoddy, 1980); during the past decade many women in various West African countries have improved their businesses by grouping together and using a mechanical grater and often also a press.

- *Adaptation to management and marketing conditions.* Technology intended to reduce women's workload is often too expensive or demands too much effort to make it economically viable. Much cereal and oilseed processing equipment, although relatively small, has too large a capacity and requires a fairly high level of management and maintenance experience if it is to be profitable at village level. The capacity utilisation level that will make the installation profitable often demands a larger quantity of raw materials input and product output than is normal in the traditional process. As a result, the group running the enterprise is unable to finance maintenance and repair costs, and the equipment eventually stands idle. At the organisational, technical and economic levels, the technology goes beyond solving the problem the processing group wanted to solve. Neither they nor the transfer agents possess adequate experience in industrial processing. An example of a processing business becoming too complex following the introduction of new technology was given earlier for potato processing (Scott *et al.*, 1992c). Another problem is that while the introduction of labour-saving technologies may have a

beneficial effect on women's welfare by reducing the physical effort required to process many foods (Barret and Browne, 1994), it does not necessarily solve the problem of how women can generate income during the time saved. Rural women have limited income-generating opportunities, and often in the time saved by using new equipment they are unable to gain sufficient revenue to cover equipment costs, much less to make a profit (Schoonmaker-Freudenberger, 1994).

Selection guidelines

On the basis of the types of experiences described above, some authors have drawn up lists of criteria for technology selection for a given situation. The lists devised by Fellows and Hampton (1992) and Treillon (1992), for example, cover the following points:

- Technical effectiveness (whether the equipment will do the job required at the intended scale of production);
- Relative costs of the equipment and its maintenance;
- Operating costs and overall profitability;
- Conformity with existing administrative and production conditions (whether, for example, the need for investment capital and a certain level of production organisation corresponds with existing credit services and labour relations);
- Conformity with the existing supplies of raw materials and the marketing opportunities;
- Social effects, such as displacement of the workforce;
- Training and skill levels required for equipment operation, maintenance and repair;
- Health and safety features and environmental impact;
- Flexibility to perform more than one function;
- Compatibility with other parts of a process and stages in the food chain.

These criteria should be used not as a checklist but rather as a set of guidelines to help both the processor and facilitator (technology transfer or extension agency, development organisation, research institution, etc.) make the right decisions when selecting the technology. In reaching these decisions, the facilitator should use a participatory approach, such as that outlined in Figure 6 for rural communities and small-scale enterprises.

Drawing on case studies on technology dissemination and on methodologies developed to promote a participatory approach – including Participatory Technology Development (PTD) (Bliek and Veldhuizen, 1993) and Farmers' Analysis-Choice-Experiment (FACE) (Chambers and Toulmin, 1991) – five main stages in the technology selection and development process can be defined (Bruinsma *et al.*, 1996):

1 *Identifying needs and setting priorities.* This should be the task of the target group itself, to ensure that real needs are identified. The facilitator should act only as a catalyst, and can be of great assistance in supplying information on alternative solutions/technologies.

ACTIVITIES BY THE TARGET GROUP	NEW ROLE FOR OUTSIDERS *(scientists, extension and NGO officers, etc.)*	
	PILOT	
Analyse: Identify needs, problems, opportunities and priorities	Convene, catalyse and advise	(1)
Choose a solution / technology	Search for and supply technologies	(2)
Experiment and adapt	Support and consult	(3)
	PRODUCTION	
	Support to start local production of equipment	(4)
	DISSEMINATION	
Analysis Choice Experiment	Dissemination (an extension activity, as during the pilot phase but much less intensive)	(5)

FIGURE 6 Relationship between target group and facilitator during participatory technology development and dissemination
Source: Adapted from Chambers and Toulmin, 1991

2 *Preliminary choice between the alternatives.* This is the task of the target group.

3 *Testing and adapting technology.* This is mainly the target group's responsibility, with the facilitator providing some support. It may lead to the final choice of a technology which will provide a solution for a processing group or enterprise. To facilitate the decision-making process involved in this and the previous stage, an effective measure is to organise demonstrations of equipment. This could be done by arranging visits to other enterprises or communities, where target group representatives can see the equipment in operation and discuss it with the owners. Information on organisational aspects can also be gathered and evaluated during such visits. To many development agencies, cooperative action seems to be a logical way of organising things, but it often leads to an unsustainable form of management. Much time should be allowed for reflecting on different options and studying their effectiveness. Applying this approach might have prevented many negative experiences (resulting, for example, in the many village mills now standing idle). FAO has drawn up a useful checklist for evaluating and implementing grain milling projects (Schoemaker, 1995).

4 *Equipment production, adaptation, repair and maintenance.* To stimulate the introduction of technology, the facilitator may also have to provide or mediate for additional technical and financial (credit) support to ensure, as far as possible, that equipment can be bought

and repaired locally. The local manufacture of equipment is a good way to ensure this, but it is not a solution for all equipment or in all circumstances. This point is discussed in more detail below.

5 *Dissemination of technology to other enterprises or communities.* The most important role that facilitators should play is to provide information and support visits to enterprises to enable people to study and compare equipment and the organisation needed to operate it effectively. They should also encourage local workshops producing the equipment to put great effort into promoting it.

Local manufacture of equipment

Many projects have shown that a good supply of spare parts and repair services is much more likely if the equipment is produced by local artisans (FAO, 1992; Wanders, 1996; F. Troude, pers. comm.). This production needs to be encouraged by giving technical support and by providing assistance with regard to the supply of raw materials and for product marketing and promotion (an element often lacking in development projects). Various institutions have now built this type of support into their projects; these include CIRAD (F. Troude, pers. comm.), Midway Technology Ltd, a consultancy firm for industrial development (P. Fellows, pers. comm.) and the Institute for Agricultural Mechanisation (IMAG) (Wanders, 1996). Credit schemes may be necessary, and care should be taken to ensure that equipment manufacturers can guarantee after-sales technical assistance and provide training in equipment operation and maintenance.

Unlike most other West African countries, Senegal imports very little in the way of cereal mill equipment. Most mills produced locally are the hammer mill type, with fixed hammers; elsewhere in the region disc mills are more common and many are of Indian origin. The first hammer mills were introduced in Senegal by a French company in the 1950s (Treillon, 1992). Local workshops carried out maintenance and repair work and also produced mills based on the imported models. Later, development agencies, including Groupe de recherche et d'échanges technologiques (GRET)/Environnement et développement du tiers-monde (ENDA), provided assistance aimed at stimulating local manufacture and the standardisation of hammer mills. Important factors in this strategy were that fixed-hammer mills are relatively easy to construct and that they produce a fairly coarse flour, which is more popular in Senegal than the fine flour produced by plate mills. In addition, conditions for investment in local equipment manufacture were favourable at the time of the GRET/ENDA project.

Tax and import regulations have a great influence on local manufacturing. Small decorticators of both the abrasive disc type and the Engelberg type can be constructed in various countries. In Senegal, however, only 30% of the rice dehullers are locally made. Tax on imported motors is higher than that for agricultural equipment, which means that importing the whole machine is cheaper than importing the motor and constructing the machine locally (M. Havard, pers. comm.).

In various African countries there are programmes supporting local equipment manufacture. Some of these are described here.

- *Ghana Regional Appropriate Technology Industrial Service (GRATIS).* GRATIS supports small-scale equipment manufacturing enterprises, many of which produce food processing equipment. It has set up Intermediate Technology Transfer Units (ITTUs) in all 10 regions of Ghana which provide assistance to enterprises through on-the-job apprentice training, a machine tool hire-purchase scheme to improve manufacturing capacity, a working capital scheme, and a special programme to support rural and women's industries (RAWI). Technologies are transferred through liaison with national and international institutions such as IITA, the Intermediate Technology Development Group (ITDG) and the Kumasi University Technical Consultancy Centre (TCC). An example is the manufacture in small-scale foundries of grinding plates for corn mills.

- *International Institute of Tropical Agriculture (IITA).* The post-harvest technology unit at IITA in Ibadan, Nigeria promotes equipment manufacture in other countries by providing designs of models that have been tested (Jeon and Halos, 1992). For example, in 1995 the unit helped set up a workshop for equipment manufacturers in the GRATIS-supported ITTU for the Cape Coast region in Ghana.

- *International Labor Organisation (ILO).* ILO assistance for equipment manufacturing takes various forms, including support for artisans forming associations. In collaboration with TOOL, ILO is implementing the Farm Implements and Tools (FIT) programme, which began in Ghana and Kenya and will eventually cover six countries. The programme helps entrepreneurs develop a market-oriented approach, seeks ways of strengthening manufacturers' associations, gives advice on technical improvements, encourages participatory technology development and identifies ways of strengthening private sector linkages.

- *Midway Technology Ltd.* Based in the UK, this consultancy firm regularly organises training programmes in Ghana and Uganda on "Food Processing as Industrial Enterprise". Topics covered in the programmes include equipment manufacture. Midway cooperates with local private sector bodies such as the Uganda Manufacturers Association (UMA). There is a clear difference between the GRATIS approach and that used by the ILO and Midway. Whereas the GRATIS programme involves establishing a heavy infrastructure through the ITTUs and receives substantial technical assistance from the Canadian International Development Agency (CIDA) and the EU, the ILO and Midway programmes are more modest, with programme representatives working on a short-term basis as facilitators.

- *Technologie Overdracht Ontwikkelings Landen (TOOL).* In Zimbabwe, the TOOL Foundation provided assistance to Ranche House College in collaboration with advisors from several local institutions: Tanroy Engineering, an equipment manufacturer; IT-Zimbabwe; and the Agricultural Engincering and Development Technology Centre at the University of Zimbabwe (J. Evers and F. Korthals-Altes, pers. comm.; M. Gwirize, pers. comm.)

- *Direct assistance to manufacturing workshops.* The assistance provided to a workshop established by the Office du Niger in Mali is given here as an example of direct assistance. In the rice growing region covered by this government institution a workshop was set up to manufacture rice threshers (Votex Ricefan model), with assistance from a Dutch institution and a private company. Production of conventional threshers (large tractor-driven machines) had been managed by the Office du Niger, but within a few years the workshop took over all production of threshers. There are now about 700 small Ricefan units in the region, owned by village associations of farmers and operated and managed at village level. Repairs are carried out by the farmers themselves, assisted by village blacksmiths. The reasons for the success of this venture can be summarised thus (Wanders, 1996):

  - Favourable political and social environment;
  - Profitability of using farm equipment (which strengthened farmer associations);
  - Availability of locally made and adapted farm equipment with adequate after-sales services, enabling field operations to be carried out in a timely and correct manner;
  - Good support measures, particularly in the initial phase (including training, extension and credit);
  - Sustainable local manufacturing based on commercial cooperation.

Enterprise development

Assistance to small-scale rural enterprises using a participatory approach will lead to the sustainable development of these enterprises only if it involves supporting the initiatives of entrepreneurs. In the African economic environment these entrepreneurs are often women seeking some (additional) income, as well as men and women interested in business-oriented production and trade. Extending farmers' activities from producing crops to processing and marketing these crops may be complicated but there is room for individual (often female) entrepreneurs and groups to produce for sale intermediary products (such as flour) and ready-made products (such as snacks) from cereals and root crops. For those entrepreneurs with experience in producing cereal flour or root crop products such as *gari*, there is a small market for prepacked products (couscous, pasta, baby cereals, etc.). To develop these processing activities into a business, however, requires a market-oriented approach based on knowing what the market wants and consumers can afford.

Intervention strategies

There are various intervention strategies for stimulating the development of small enterprises and the dissemination of technologies appropriate for different stages in the food chain. The most important issues in these strategies relate to: participatory technology development and dissemination; demand-led innovation; the supply of services and information; management and organisation; entrepreneurship development; and training.

Participatory technology development and dissemination

This was described earlier in this chapter, under "Technology selection and dissemination". In this process, the term "target group" is broadly defined to include producers, processors and consumers. A participatory approach is important in problem analysis, priority setting and identifying product and marketing opportunities. Interventions by the facilitator could take the form of arranging exchange visits to help processors and equipment manufacturers in their selection of both processing and manufacturing technologies. Markets and trade fairs are an effective means for equipment manufacturers to promote equipment they have developed.

Demand-led innovation

The identification of product and marketing opportunities involves assessing the market demand for products and the conditions under which they can be produced at competitive prices (Wheatley and Scott, 1992). Many projects set up to produce composite flours as a substitute for wheat or rice imports failed because they were rather technology-oriented not sufficiently product-oriented; most consumers wanted bread made from wheat flour, not from composite flours. The same was true for maize grits, produced as a substitute for rice but not accepted by consumers. Such foods risk being seen as "poor man's food". These and other experiences, such as those for sweet potato processing and weaning food production described by Truong (1992) and Meerendonk and Würdemann (1996), respectively, underline the importance, at the start of a project, of:

- Identifying potentially successful products;
- Identifying the market demand for such products;
- Conducting a cost-benefit analysis for such products.

An example of a facilitator making products rather than technology the focal point of enterprise development is provided by an NRI research project on the quality and safety of traditional sorghum foods in India. This project is using participatory appraisal and market survey techniques to assess the technical, policy, economic and social factors which could affect the utilisation of sorghum in the States of Maharastra, Karnataka and Andhra Pradesh. The work involves developing and testing rapid market analysis (RMA) methods for small-scale enterprises (Bottema, 1992; H. van de Meerendonk, pers. comm.).

Services and information

Small-scale enterprises need information and advice on a wide range of issues, such as markets, available technology, technology selection and access to credit. Facilitators should not therefore restrict themselves to providing assistance in one area only, such as technology

consultancy. This was one of the findings of an analysis conducted by Bohnstedt (1996) of the factors involved in promoting food production enterprises.

Facilitators should build a good network for the supply of information and services. For example, they should be aware of organisations providing credit and/or management assistance to small enterprises and should build links with technical institutions providing information on product and process development. They should also have access to databases on appropriate technology in order to be able to give enough advice to small enterprises during the technology selection stage.

CIRAD-SAR holds extensive information on traditional technologies on its ALTERSIAL database, which it intends making operational for the Projet AVAL, possibly through the Internet. It is also considering extending the information to include improved and modern technologies. GRET/Réseau technologie et partenariat en agroalimentaire (TPA) has a directory of information for food processors based on its network of practitioners and information sources. ITDG has published several books on topics relevant to small-scale food processors (e.g., Clarke, 1987; Fellows and Hampton, 1992; Carruthers and Rodriguez, 1994). In Burkina Faso, GTZ and the German Appropriate Technology Exchange (GATE) have set up the Service inter-africain de technologies appropriées (SIATA) network and a database on appropriate technology for use in West Africa, and have established links with NGOs in other countries. A similar network, the Regional Appropriate Technology Information Service (RATIS), exists in Eastern and Southern Africa (Seifert *et al.*, 1994). In some countries there are information service centres which help small and medium-scale enterprises gain access to information; in many places, however, the transaction costs are too high for these enterprises during their establishment phase.

Management and organisation

Good business management is indispensable for the successful adoption of technology and sustainability of an enterprise. Simple as well as more complicated processing technologies can be managed by both individuals and groups or cooperatives. Facilitators should, however, provide training in business management as well as in equipment operation and maintenance. A commercial approach should be built into the project from the outset, with attention paid to such factors as management structure and ownership issues (Zoomers, 1995).

Improvements in processing often involve a change in the organisation of the processors and in the volume of raw materials to be processed if the new technology is to be economically viable. The community or group involved needs to have sufficient management and technical experience to be able to run the operation successfully. If this experience is lacking, a private entrepreneur should be approached to take on this task. Various forms of organisation are possible:

- The village cooperative or interest group runs the processing plant and pays a salary to the machine operator(s) and labourers;

- The village cooperative or interest group leases equipment from a local workshop with sufficient experience in equipment manufacture and maintenance;

- A private enterprise functions as a service mill and processes small batches for individual families, or larger batches on contract for the village cooperative;

- A private processing enterprise operating on a fully commercial basis buys raw materials from the village and the surrounding area.

A combination of these types of organisation is also possible. For example, small private entrepreneurs may lease equipment from a workshop that provides maintenance services and spare parts. This approach has been proposed for a post-harvest and agricultural engineering project in The Gambia (H. van de Meerendonk, pers. comm.). An analysis made during this project showed that rice threshers and dehullers are mainly privately owned and operated, while coarse grain mills are owned by villages or communities. Private rice dehullers are more commercially oriented and operate at far lower transaction costs than village management committees. When a village mill breaks down, transaction costs are very high and the women who manage the mill are forced to resort to hand pounding. Spare parts and maintenance services for the mills are provided by a government agency, but in an ineffective way, with the result that many mills stand idle for long periods. The private sector has not yet taken up the distribution of spare parts but experience in importing these parts does exist and local artisans have the knowledge required to handle the maintenance. It was therefore proposed that a semi-private sector system be set up as a step towards a fully privatised decentralised network for the supply of equipment and spares and for repair and maintenance services. In this system small enterprises, particularly those lacking capital, acquire equipment under a type of leasing arrangement from local workshops with sufficient knowledge of the equipment and the diesel engines that run them.

In food processing enterprises women are often important, both as entrepreneurs and as labourers. When developing food processing enterprises one should therefore be aware that specific gender problems are involved. It is important to pay attention to the effects that changes have for the women involved and to ask explicitly what women themselves would prefer in a certain situation. The introduction of organisational changes (for instance, as a result of an increase in production capacity because of mechanisation) is often not found to be very attractive. Women's main reason for being involved in processing or in any commercial activity is not to make large profits but to gain some additional income and obtain better economic security for the family. Micro-enterprises in particular are attractive to women because of the flexible nature of the work, which makes it easier to combine work with domestic responsibilities. Consequently, it will also not be easy to expand their business because their family duties generally do not allow them to take risks and carry the obligations

involved in larger businesses. Women certainly need greater access to credit and business advisory services; such services are generally not easily accessible to them (Baud and de Briujne, 1993). Women welcome credit schemes which make them more independent and their business more economically secure but they tend to be less keen on using credit to expand a business significantly. A project in Burkina Faso aimed at expanding businesses run by women provides an example of this (Wagenaar, 1991). The above-mentioned semi-private sector system would be an interesting option in that situation. Care would need to be taken, however, not to change gender relationships in a way that would be unfavourable for the women. For such cases, Schoemaker (1995) provides a useful guide to the factors to consider when implementing a grain-milling project involving women's groups.

Entrepreneurship development

Closely linked to the need for good management is the need to stimulate entrepreneurship. Enterprises should be encouraged to adopt a dynamic approach whereby they are constantly investigating ideas for new products and looking for new markets for existing products. Technology transfer in this case becomes a continuous process which enables enterprises to respond to changing market conditions.

The KIT projects on weaning food production illustrate the importance of not basing an enterprise on one product only, but rather on outputting different products in different price categories for different markets. Producing only one product, with a relatively small value-added component, is usually not sustainable for a small enterprise (Meerendonk and Würdemann, 1996). A useful measure prior to formulating a business plan is to conduct a SWOT (Strength, Weaknesses, Opportunities and Threats) analysis in order to assess the performance of the enterprise in comparison to the rest of the national economy (Würdemann and Meerendonk, 1996).

Diversification into producing snacks and pre-cooked foods is an interesting option but carries some risks. The market for many traditional products produced as convenience foods is relatively small; for cultural and economic reasons, most people prefer to prepare traditional dishes at home. To produced larger quantities of products such as couscous that cannot be easily produced in large quantities at family level, it is cheaper to make use of a custom mill or hired labour than to buy the pre-cooked food. Pre-cooked (and packed) food products seem to be bought only for specific purposes such as for preparing sweet couscous. Some market women have also discovered the advantages of the product; they humidify and heat the pre-cooked product to sell in small quantities as freshly prepared couscous.

The relationship between processor and consumer is important in enterprise development. It seems that the nearer the consumer is to the processor, geographically, the more the consumer is likely to trust the processor (P. Fellows, pers. comm.). Consumers mistrust various types of processing or processed products, but this may vary by region. Maize flour, for example, is a commercially available and accepted product in many Eastern and Southern African

countries but much less so in West Africa. Dehulled rice is accepted everywhere, but this is not the case for dehulled millet and sorghum.

Quality characteristics, such as variation in organoleptic aspects and shelf life, play an important role in determining the production process most likely to succeed. In the UK, for example, consumers accept bread produced industrially, but in France consumer preferences have led to bread production being mainly an artisanal activity. Some products do not benefit from mechanisation, especially with regard to marketing them in urban areas. This is the case to some extent with processing cassava to make *gari*. There are various examples where women who formerly produced small quantities of *gari* on an individual basis increased production by the cooperative buying of cassava, using a grating machine and a press and marketing larger quantities. This led to increased market demand and an incentive for cassava producers to improve the production process. Going a stage further, however, by putting *gari* production onto a fully industrial footing was not a success. It proved difficult to control processing conditions such as temperature-time-humidity interactions so that the right flavour would develop during frying.

Training

Providing training for facilitators and entrepreneurs in market analysis and product selection is crucial to successful intervention strategies and enterprise development. Entrepreneurs need to have access to specialists, including equipment suppliers and manufacturers, to help them select the right production process and equipment. Training is also important in how to conduct a feasibility study, formulate a business plan and seek appropriate credit.

Further study is needed on how facilitators can best carry out their tasks in a systematic way, as the literature available on this subject is fairly minimal. Documented knowledge tends to be limited to lists of criteria and participatory methodologies and to the intervention strategies discussed earlier. It is important, therefore, that experiences in small-scale enterprise development within the context of the food chain be collated and that the role of local or foreign institutions be analysed. Some work in this field is being conducted by FoodNet/Réseau sur la transformation des produits agroalimentaires (RESAA) (FAKT, 1996). The aim of this work is to help establish bridges between various groups and organisations – local equipment manufacturers, food processing entrepreneurs, and technical and academic institutions such as the Technology Consultancy Centre at the University of Kumasi, Ghana, and the Development Technology Centre at the University of Zimbabwe.

After finishing this study, further initiatives supported by CTA have been taken by CIRAD, FAKT and KIT. The small-scale food processing subsector in Tanzania and Uganda has been assessed and workshops involving the main stakeholders in the subector were organised in Malawi and Uganda. Studies are being carried out and workshops will be organised in West and Southern African countries during 1999.

Chapter 5

CRITICAL ISSUES FOR DEVELOPMENT

This review of the literature and project experiences has highlighted a number of issues that need attention. Suggested ways of addressing these issues are given here; some of these measures are supported by research results and documented experience, while others are based on more limited information but nevertheless appear to be worth considering. The recommended actions focus first on cereal and root and tuber crop storage and processing opportunities, then on ways to foster enterprise development, and finally on specific ideas for further research, linked to ongoing research in various institutions.

Storage and processing

Cereals

Storage

- Disseminate more information on the damage caused by the larger grain borer in maize and dried cassava and on how to control this storage pest;
- In the transfer of low-cost on-farm storage improvements, draw together information on practical experiences with these technologies and ensure effective dissemination of the information;
- Provide information on good storage practices to NGOs setting up cereal bank projects, and refer them to publications such as those produced by the FAO on establishing, operating and maintaining cereal banks (Kat *et al.*, 1992).

Course grain processing

- Information on mechanised threshing, dehulling and milling and on research results and the transfer of secondary processing technologies needs to be more widely disseminated;
- The results of the efforts of the UNIDO project in Burkina Faso and Mali to reduce processing costs could be of interest to those involved in providing milling equipment in other countries;
- Wider distribution of locally constructed, small-capacity (50–150 kg/h) Mini-PRL dehullers and mills in urban and semi-urban areas (Mbengue and Havard, 1992) should be considered.

Rice processing

- Minimills have not yet led to significantly lower milling prices, and efforts should be made to promote the local manufacture and distribution of small-capacity (100–150 kg/h) rice dehullers (Mbengue and Havard, 1992);

- The results of CIRAD's research on the feasibility of semi-industrial rice mills taking over the role of State-owned industrial mills following market liberalisation should be circulated when they become available;

- The results of the NRI's research on improving the efficiency of the parboiling process should be circulated when they become available.

Secondary processing

- Disseminate information from CIRAD's Projet AVAL when it becomes available. It is important to gain a better understanding of the intercultural exchange of food processing and preparation practices, of the marketability of "transferred" products and thus of diversification options for small-scale enterprise development;

- Disseminate information from the KIT projects on processing and marketing weaning foods.

Root and tuber crops

Storage

- Disseminate information from the NRI work on cassava and sweet potato storage to improve the marketing of these commodities. This information should be made available not only in English but also in French and Portuguese and could include, for example, videos in these languages;

- Information from the NRI project on "Transfer of Needs Assessment Methodologies and Post-harvest Technologies for Non-grain Starch Staple Food Crops" should be disseminated throughout Africa, not only to those countries benefiting from DFID assistance;

- Disseminate information on the diffused light storage (DLS) technology for seed potatoes.

Cassava processing

- The technology developed in South America for the use of fermented cassava starch in various products looks promising, but before disseminating such technology consumer tests with these products are essential;

- For NGOs and other organisations active in rural development, provide an overview of technical and economic information on small- and medium-scale *gari* production technologies and information on relevant training and research facilities.

Other root and tuber crop processing

- There is now a variety of technologies available for the diversification of potato and sweet potato processing, but marketing surveys need to be conducted before these technologies are disseminated;

- The results of CIRAD's research on the yam processing technology for making cossettes, which could increase market demand for yam in many countries, should be disseminated when they become available.

Enterprise development

Training

- Provide training for development agency personnel on how to help local institutions and entrepreneurs conduct market analyses, select production processes and technologies, formulate business plans and secure financing.

Marketing

- Disseminate information on inventory credit systems (Coulter and Shepherd, 1995) to NGOs and other development agencies;

- Promote methodologies for rapid rural market analysis;

- Investigate the relevance of integrated chain management strategies with a view to upgrading marketing systems in Africa and implementing differentiation policies for small-scale food processing enterprises.

Organisation

- The results of the NRI's research in Ghana and Uganda on farmer-controlled enterprises (Coulter *et al.*, 1995) should be disseminated when available to help determine the organisational factors and intervention approaches needed for a successful and sustainable food processing enterprise;

- Technology introduction and development activities should be based on a participatory approach, with particular attention being paid to gender and employment issues.

Product development

- Product diversification opens new outlets for agricultural raw materials and is important for enterprise development, but must be linked to market analysis. This is the case for the development of processed potato and sweet potato products and for the development of processing equipment, such as that used for making couscous.

Information services

- As stressed during a CTA workshop in October 1996, attention should be paid to developing further methodologies for delivering support services with regard to information and equipment brokerage, skills development and credit brokerage.

Further research

- Conduct research on group dynamics in relation to technology adoption. The NRI studies on group approaches (described in Chapter 1) constitute the only known work being done on this topic. A well-chosen case may clarify why group enterprises work in some situations but not in others. Further studies are necessary to develop group approaches for sustainable processing enterprises.

- Conduct in-depth analyses to find viable solutions to household-level cereal processing problems. These could include an analysis of the transfer of the practice of threshing grain before storage (which may have implications for the daily threshing task faced by women) and a search for household-level solutions using technology transfer, as in the case of improving dehulling by adding wood-ash. It would also be useful to discover if there is any information on the effectiveness and adoption of the ATI-improved pestle for pounding. An analysis could also be made of the UNIDO/IFAD sub-regional project in West Africa aimed at improving village-level milling and reducing milling costs.

- Analyse the introduction of dehullers in rural areas to determine the most favourable conditions for such introductions.

- Analyse the NRI work on developing needs assessment methodologies for non-cereal starch crops in order to produce guidelines for needs assessment studies on food processing activities in general.

- Study the role of equipment manufacture in the transfer of food processing technologies, using the cases from Ghana or Uganda as well as experiences from other projects (such as the TOOL project in Zimbabwe based on cooperation between a local entrepreneur, a training institution and local and foreign advisors; and the GRET/ENDA work in Senegal on disseminating cereal mill technology).

- Gather information on experiences in rapid market appraisal (RMA) and produce a manual on RMA for the small-scale food processing sector.

- Gather information on experiences in and support programmes for local equipment manufacturing and produce a manual based on this information aimed at improving the quality of local manufacturing and the efficiency of locally built machines. The manual should include a list of important designs and the addresses of organisations that could provide designs, technical drawings and technical assistance for the manufacture of equipment that has been tested and adopted.

- Study options for distribution and management procedures for food processing equipment, such as leasing, and the conditions under which enterprises using such arrangements could work effectively.

ANNEXE 1

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ANNEXE 2

Food processing research and development projects

This annexe provides an overview of recent research and development projects. A selection of project records is given, as well as abstracts of publications that refer to projects or provide their results. Because it is a selection made by the author and not all fields available on the databases are included, the list should be seen only as indicative of the kind of activities taking place. Many of these activities, however, will have finished by the time this study report is published.

The full meaning of the abbreviations used in this annexe, and the databases used for information on research and development projects and on literature, are given at the end of the annexe.

CEREALS

TI **(Post-harvest equipment for cereals in Senegal)**
OT Le materiel de traitement post-recolte des cereales au Senegal
AU Mbengue, H.M.
SO Revue Senegalaise des Recherches Agricoles et Halieutiques (Senegal). 1989, v. 2(1) pp. 68-75, 9 ref.; summaries (En, Fr, Pt)

TI **Postharvest technology (Senegal) – Phase I (ID: 2228)**
Postharvest technology (Senegal) – Phase II (ID: 2288)
IA International Development Research Centre
CO Mr Gora Beye, Centre National de Recherches Agronomiques, Bambey, Senegal

TI **Cereal processing (Senegal) (ID: 2241)**
IA International Development Research Centre
CO Mme Therese Basse, Institut de Technologie Alimentaire (ITA), Dakar, Senegal
FU Ms Mary Campbell, ISD, IDRC, PO Box 8500, Ottawa, ON, Canada K1G 3H9, Tel: (613) 236 6163, Telex: 053 3753, Cable: RECENTRE OTTAWA, Fax: (613) 238 7230

TI **Qualité du produit et transformation (maïs, sorgho), Projet 1995/70/CER/140, CIRAD/CA, entre outre: 1 roulage mécanisé de farines de céréales, 2 pates alimentaires 3 produits nixtamalisés, 4 dégermeur à maïs semi-industriel**
CO C. Mestres
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **(Design of a couscous processing machine)**
OT Conception d'un rouleur a couscous
AU Marouze, C.
SO Montpellier (France), CIRAD-SAR, 1993, 25 pp., tables; summary (Fr)

TI **Qualité du grain (maïs, sorgho), Projet 1995/70/CER/141**
CO G. Fliedel
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **(The processing of farm products: grain cleaning, standing cereals thresher. Final report)**
OT Traitement des produits agricoles apres-recolte: nettoyage de grains, egreneuse de cereales sur pied. Compte-rendu final
AU Marouze, C.
SO Montpellier (France), CIRAD-SAR, 1992, 11 pp., figs, tables; summary (Fr)

TI **The Royal Tropical Institute's new approach to the production of local weaning food**
AU Dijkhuizen, P., KIT, Amsterdam
SO GASGA Newsletter (Australia) no. 13, pp. 4-5

TI **Postharvest grain systems (Tanzania) (ID: 2508)**
IA International Development Research Centre
CO Mr Donald Lutende, Uyole Agricultural Centre, PO Box 400, Mbeya, Tanzania

TI **Réseau sur la Conservation Post-Récolte des Denrees Alimentaires (GRENIER)** (ID: 2647 SIS/SPAAR)
IA Association des Universités Partiellement ou Entièrement de Langue Française (AUPELF)
CO AUPELF

TI **Grain storage (Zimbabwe)** (ID: 2427)
IA International Development Research Centre
CO Mr Yemi Katerere, 45 Gordon Avenue, PO Box MP 83, Mount Pleasant, Harare, Zimbabwe

TI **Optimising the use of fumigant gases (ID: 5761)**
IA Overseas Development Administration (NRRD)
CO Dr P. Golob, Natural Resources Institute

TI **Comprehensive evaluation of small scale grain storage (ID: 4692)**
IA Overseas Development Administration (NRRD)
CO Dr M.C. Gough, Natural Resources Institute

TI **Rural storage structures (ID: 4271 SIS/SPAAR)**
IA FAO, Tanzania

TI **Biological integrated control of the larger grain borer, *Prostephanus truncatus* Horn (ID: 3907 SIS/SPAAR)**
IA Institut für Phytopathologie, Arbeitsgruppe Vorrat, Universität Kiel, Germany
CO Prof. Dr F.A. Schultz/Dr G.A. Laborius

TI **Support to small-scale grain handling and storage following market liberalization in Southern Africa (ID: 5784 SIS/SPAAR)**
IA Overseas Development Administration
CO P. Hindmarch, NRI

TI **Investigating the suitability of solid state fermentation (tempe) of various legumes and legume cereal mixtures in Ghana (ID: 3339)**
IA IFS
CO Ms Alice Hayford, Food Research Institute, Accra, Ghana

TI **Appropriate technology international II (ID: 1945)**
IA US Agency for International Development
CO Appropriate Technology International, 1331 H Street, NW, Washington DC 20005, USA, Tel: (202) 879 2900
Various institutions: IER (Bamako), IRA (Yaounde), INERA (Kinshasa), Nat. Milling Co. (Dar es Salaam), BTC (Gaborone)
NA ...Other African agricultural projects include: grapple processing, Botswana; maize plate mills, Cameroon; maize planter, Cameroon; mini-dehullers, Mali; sunflower seed oil presses, Tanzania; and hydro-powered grain mills, Zaire

Sorghum and millet

TI **(Trial of a millet and sorghum huller)**
OT Essai d'une decortiqueuse a mil et sorgho
AU Toure, M.A.
AD Centre d'Etudes et d'Experimentation du Machinisme Agricole Tropical (CEEMAT), CIRAD, Montpellier, France
SO Montpellier (France), CNEARC, 1989, 73 pp., figs, tables, ref.; summary (Fr)

TI **Processing and utilization of sorghum in West Africa (ID: 5895 SIS/SPAAR)**
IA ICRISAT
CO Debrah, S.K.

TI **Improved dehulling systems (Botswana) (ID: 2409)**
Grain dehulling (Uganda) (ID: 2410)
Grain dehulling (Uganda) – Phase II (ID: 5333
Grain dehulling (Malawi) – Phase I (ID: 2421)
Grain dehulling (Malawi) – Phase II (ID: 4207)
Dehuller development (Senegal) – Phase II (ID: 4947)
Dehuller testing (Niger) (ID: 2456)
Dehuller testing (Niger) – Phase II (ID: 4205)
Mini-dehullers (Zimbabwe) – Phase I (ID: 2417)
Mini-dehullers (The Gambia) – PhaseI (ID: 2411
IA International Development Research Centre (IDRC), Ottowa, Canada

TI **[Network on Sorghum Milling/Dehulling] (ID: 2648)**
IA IDRC

TI **Popularization of sorghum dehulling and milling technology (Tanzania) (ID: 1070)**
IA IDRC

TI **Sorghum processing pilot (Kenya) (ID: 2479**
Sorghum milling (Ethiopia) (ID: 2338)
Sorghum milling (Zimbabwe) (ID: 2339)
Sorghum milling (Sudan) (ID: 2271)
Sorghum milling (Tanzania) – Phase I (ID: 2292)
Sorghum milling (Tanzania) – Phase II (ID: 1062)
IA IDRC

TI **Sorghum utilization (Ethiopia) (ID: 2302)**
Sorghum utilization (Tanzania) – Phase I (ID: 1059)
Sorghum utilization (Tanzania) – Phase II (ID: 2476)
Sorghum/millet/cowpea utilization (Burkina Faso) (ID: 2276)
IA IDRC

TI **Sorghum and millet sub-sector (Tanzania) (ID: 4198)**
IA IDRC

TI Labour-saving techniques in food procesingg: rural women and technological change in Gambia **<Document Title> Working Paper, African Studies Center, Boston University**
AU Nath, K. PY – 1985
AB The paper describes the methodology used in developing a project design for the introduction of sorghum and millet hulling machines and flour milling units in rural areas of the Gambia. The objective of the project is to provide rural women with labour-saving technologies.... Execution of the project is found to develop women's managerial skills and business entrepreneurship.

TI **Semi-wet milling of pearl millet for reduced goitrogenicity (ID: 1741)**
IA Overseas Development Administration (NRRD)
CO Dr D.A.V. Dendy, Natural Resources Institute

TI **Improvements to the processing of millets (ID: 4766)**
CO Dr D.A.V. Dendy, Natural Resources Institute

TI **Improvements to the processing of sorghum, especially for non-traditional uses: Milling (ID: 4682)**
New foods from sorghum (ID: 4679)
By-product utilisation (ID: 4680)
CO Dr D.A.V. Dendy, Natural Resources Institute

TI **Improvements to the processing of sorghum, especially for non-traditional uses: Dehulling (ID: 4678)**
CO Mr S. Turner, Natural Resources Institute

TI **Improved processing of sorhum and millet in semi-arid production systems of India and east Africa, NRI project R6336**
SO Food processing research in the tropics and subtropics, ECART, Bonn, 1995

TI **Development of new food products from sorghum in Kenya (ID: 2878)**
CO Dr D.A.V. Dendy, Overseas Development Natural Resources Institute (ODNRI)

TI **Improvement of dolo fermentation: a local beer produced from millet (ID: 3380)**
IA IFS
CO Mr Tiga Rigovert Yameogo, Departement de Biomasse, Institut Burkinabe de l'Energie, BP 7047, Ouadougou, Burkina Faso

TI **Plant breeding in relation to the utilisation of sorghum and millet for food, beverages and animal feed (ID: 3603 SIS/SPAAR)**
IA SACCAR/ICRISAT

TI **Pearled sorghum market survey (Kenya) (ID:2480)**
IA International Development Research Centre
CO Mr Noah Chune, Kenya Industrial Research and Development Institute, PO Box 30650, Nairobi, Kenya

TI **Marketing sorghum products (Lesotho) (ID: 2485)**
IA International Development Research Centre
CO Mr Palesa Matete, Division of Agricultural Research, Ministry of Agriculture, PO Box 829, Maseru, Lesotho

TI **Millet threshers (Mali) (ID: 2290)**
IA International Development Research Centre
CO Mr Dramane Zerbo, Division du Machinisme Agricole, Ministere du Developpement Rural, Bamako, Mali

Rice

TI **(Study of the conditions for introduction and adoption of mechanization equipment and technology by rice growers in the Lake Alaotra region, Madagascar)**
OT Etude des conditions de diffusion et d'adoption du materiel et des techniques liees au machinisme par les exploitants rizicoles au Lac Alaotra, Madagascar
AU Raoelina, T.A.
AD Departement Systemes Agraires (DSA), CIRAD, Montpellier, France
SO Montpellier (France), CNEARC, 1989, 117 pp., tables, ref.; summary (Fr)
AB The diffusion and adoption of rice equipment and technologies were studied in the Lake Alaotra region, Madagascar... ...determine basic data on current conditions of use and management of the equipment available. The second objective is to identify bottlenecks... ....technical and economic proposals are made....

TI **Machinisme agricole et technologie post-recolte dans la Vallee du Fleuve Senegal (ID: 4598)**
IA Centre d'Etudes et d'Experimentation en Mecanisation Agricole et Technologie Alimentaire (CEEMAT-CIRAD) – Division de la Mecanisation et de la Production Agricole (MPA)
CO Mr Michel Havard, ISRA, BP 420, Saint-Louis, Senegal

TI **Programme national de technologie rizicole apres recolte (ID: 5608)**
IA FAO
CO SAED (Societe d'Amenagement et d'Exploitation des Terres du Delta), 18, rue Raffanal x A. Goux, Dakar, Senegal

TI **[Semi-industrial rice processing unit in Madagascar: overview and** prospects]
AU Cruz, J.F. CIRAD/SAR PY – Aou 1992 (ID: CAB 537)
AB Dans le cadre du projet FAC/TPA intitule "Unite semi-industrielle d'usinage du riz a Madagascar", une mini-rizerie, concue par le CIRAD-SAR et realisee par la Societe GAUTHIER, a ete implantee chez un concessionnaire prive d'Ambatondrazaka au lac Alaotra...Une etude socio-economique sera realisee en 1993 pour analyser l'interet que peut presenter ce type d'equipement pour la filiere riz locale.

TI **Reseau Riz – Analyse des filieres riz en Afrique et a Madagascar (ID: 3761)**
IA Conference des Responsables de Recherche Agronomique Africains et Francais
FU Mr Ludovic Ncho Achiaye, Coordonnateur du Reseau Riz, Institute of the Savannas (IDESSA), Department des Cultures Vivrières, BP 633, Bouaké (Côte d'Ivoire), Tel: (225) 63 21 29, Telex: 69100
Mr Christian Poisson, Correspondant pour la France, CIRAD/IRAT, BP 5035, 34032 Montpellier Cedex 01, France, Tel: (67) 61 59 00, Telex: 480762, Fax: (67) 61 59 88

TI **Village post-harvest centres (Mauritania) (ID: 2328)**
IA International Development Research Centre
CO Mr Ba Mamdou Samba, Societe Nationale pour le Developpement Rural (SONADER), Nouakchott, Mauritania
NA ...Researchers will determine the most suitable postharvest system for use in a typical perimetre; establish a rice postharvest centre at Diowol; and verify the introduced system's economic, social and technical acceptability.

TI **Solar crop dryers (Sierra Leone) – Phase I (ID: 2275)**
TI **Solar crop dryers (Sierra Leone) – Phase II (ID: 2367)**
IA International Development Research Centre
CO Mr Malcolm Whitfield, Dept. of Mechanical Engineering, University of Sierra Leone, Private Mail Bag, Freetown, Sierra Leone

TI **Small-farm equipment (Ghana) – Phase II (ID: 2304)**
IA International Development Research Centre
CO Mr B.N. Ntim, Technology Consultancy Centre, University of Science and Technology, University Post Office, Kumasi, Ghana
NA ...Phase II will improve the performance and durability of the existing threshers; test and evaluate a winnower; and determine the social, economic, and manufacturing parameters of the equipment in several rice-producing regions of Ghana.

TI **Improved efficiency of low-cost small scale rice processing in south Asia and west Africa (NRI research project R6331)**
SO Food processing research in the tropics and subtropics, ECART, Bonn, 1995

TI **Surface condition of milled rice (ID: 4764)**
CO Mr P.A. Clarke, Natural Resources Institute
NA The wider objective of this project is to increase food security in the rice areas of Africa, Asia and S. America, and to improve the marketability of grain. The immediate objective is to determine the effect of milling technologies on components of rice grain quality.

TI **Development of parboiling (ID: 4763)**
CO Mr P.A. Clarke, Natural Resources Institute

TI **Design of a rice husk fuelled heat/power system (ID: 4676)**
CO Mr A.P. Robinson, Natural Resources Institute

TI **West Africa: Post harvest losses of rice (ID: 4675)**
CO Mr P. Clarke, Natural Resources Institute

Maize

TI **Economic aspects of protection of stored products: the example of maize** in the south of Togo.
TI **<Original> Aspects economiques de la protection des stocks: l'exemple** du mais dans le sud du Togo.
AU Albert, H.
PU Deutsche Gesellschaft für Technische Zusammenarbeit, Projekt für Nacherntefragen (GTZ)
PY – 1992
AB ...economic aspects of the protection of stored products; and general evaluation and recommendations for advice to be given to farmers.

TI **Traditional and industrial fermentation of maize (ID: 5671)**
IA WAU (Wageningen Agricultural University)
CO Dr Ir M.J.R. Nout, Department of Food Science (WAU)

TI **Procede de fabrication de pates de mais (ID: 2885)**
IA Commission des Communautes Europeennes
CO Mr J. Faure, Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières (IRAT/CIRAD)

TI **Anti-microbial activity of fermented Ghanaian maize dough (ID: 5466)**
IA International Foundation for Science
CO Dr Patience Mensah, Bacteriology Unit, Noguchi Memorial Institute, University of Ghana, PO Box 25, Legon, Ghana

TI **Biochemistry and technology of the preparation of fermented paste from maize in Benin (ID: 3338)**
IA IFS
CO Dr D. Joseph Hounhouigan, Section Nutrition et Sciences Agro-Alimentaires, Faculte des Sciences Agronomiques, Universite National du Benin, Cotonou, Benin

TI **Studies on spoilage and shelf-life extension of kwoka, a Nigerian traditional maize dish (ID: 3386)**
IA IFS
CO Dr Bernard J.O. Efiuvwevwere, Dept of Microbiology, Univ. of Port Harcourt, Nigeria

TI **Corn dough fermentation to produce kenkey, porridge and other Ghanaian dishes (ID: 5113 and 2940)**
IA International Foundation for Science
CO Dr Kwaku Nyako, Department of Biological Sciences, University of Science and Technology, Kumasi
CY GH Ghana

TI **Development of weaning food from local fermented food** (ID: 5162 and 3157)
IA International Foundation for Science
CO Dr Simeon Achinewhu, Rivers State University of Science and Technology, PMB 5080, Port Harcourt

TI **Economics of post harvest loss reducing measures** (ID: 3772)
IA University of Hohenheim
CO Prof. Dr. W. Doppler, Inst. 490, Universitaet Hohenheim, Postfach 700562, 7000 Stuttgart 70, Federal Republic of Germany
German Agency for Technical Cooperation (GTZ)/Project Allemand pour la Protection des Vegetaux, BP 1263, Lomé, Togo
FU Dr H. Franzen

TI **Large-scale maize storage (Togo) (ID: 2425)**
IA International Development Research Centre
CO Mr Messan Gninivi, BP 1515, Lomé, Togo
NA ...The purpose of this project is to design, develop and test a modified silo which uses water heated by solar energy to control the relative humidity of the air at a level suitable for good storage of the grain. Comparisons will be made between the performance of this modified silo and the conventional type in order to determine the advantages of the developed silo.

Other cereals

TI **Grain storage and milling project (ID: 3542)**
IA World Bank; Tanzania
CO National Marekting Company (NMC), Tanzania

TI **Nutritional and microbiological evaluation of fermented cereal foods for child feeding in Tanzania (ID: 3337)**
IA International Foundation for Science
CO Mr Wilbald Slaa Matle Lorri, Department of Food Science, Tanzania Food and Nutrition Centre (TFNC), PO Box 977, Dar es Salaam, Tanzania

TI **Reduction of antinutritive factors by the activity of lactic acid bacteria in fermented cereals, typical of sub-Saharan Africa (ID: 6375 SIS/SPAAR)**
IA Institut für Hygiene und Toxikologie der Bundesforschungsanstalt für Ernärung, Karlsruhe

ROOT AND TUBER CROPS

TI **Starch adhesives (Malawi) (ID: 5824)**
IA International Development Research Centre
FU Ms Mary Campbell, IDRC, Ottawa, Canada

TI **A Southern African Root and Tubers Crops Research Network (SARNET) (ID: 5383)**
IA International Institute of Tropical Agriculture (IITA) for cassava/International Crop Institute for Potatoes (CIP) for potatoes and sweet potatoes
FU Dr M.L. Kyomo, Director, Southern African Centre for Co-operation in Agricultural Research (SACCAR)

TI **The East and Southern Africa Root Crops Research Network (ESARRN) (ID: 2080)**
IA US Agency for International Development (USAID)/International Development Research Centre (IDRC)/International Institute of Tropical Agriculture (IITA)
CO Dr M.N. Alverez, Plant Breeder, IITA/ESARRN, PMB 5320, Ibadan, Nigeria, Tel: 400300, 400313, Telex: TDS IBA NG 20311 (Box 015), Cable: TROPFOUND, IKEJA

TI **Regional Africa Technology Transfer Project on Non-Grain Starch Staple Food Crops. NRI**
IA Overseas Development Administration
CO Dr A. Westby (NRI), Mr K.Nichol/Mr D. Crentsil (Post-Harvest Development Unit Min. of Food and Agriculture, Accra) and Dr W. Lorri/Mr G. Ndunguru (Tanzania Food and Nutrition Centre)

TI **Development and field testing of needs assessment methodologies in traditional root crop post-harvest systems. NRI project R5079 and R6317 (ID: 4837)**
IA Overseas Development Administration (NRRD)
CO Dr N. Poulter, Natural Resources Institute

TI **Post-harvest assessment of root and tuber crop storage** (ID: 4834)
IA Overseas Development Administration (NRRD)
CO Dr N. Poulter, Natural Resources Institute

TI **Post-harvest technology of root and tuber crops: cassava fermentation** (ID: 5107)
IA International Foundation for Science
CO Mr Festus Numfor, until 1992/Department of Food Science, 216 Schaub Hall, North Carolina State University, PO Box 7624, Raleigh, North Carolina 27695, USA

TI **Root and tuber crops research (ID: 1878)**
IA US Agency for International Development
CO Mr Ayuk-Takem, Director, Agricultural Research Institute (IRA), BP 2123, Yaoundé, Cameroun, Tel: 23 35 38, Telex: 1140 KN, 8512 KN
NA Develop new varieties of yam, cassava, and cocoyam and new methods of postharvest handling. Train six participants for advanced degrees in USA and six short-term programs.

TI **Cassava and sweet potato (Rwanda)** – Phase III (ID: 2505)
IA International Development Research Centre

Cassava

TI **(Integrated project for cassava utilization in Ecuador: the experience of UATAPPY in Porto Viejo)**
OT Projet integre de valorisation du manioc en Equateur: l'experience de la UATAPPY a Porto Viejo
AU Dufour, D.; Chuzel, G.
AD Systèmes Agroalimentaires et Ruraux (SAR), CIRAD, Montpellier, France
SO 1992, 20 pp., tables, ref.; summary (Fr)

TI **Improved cassava processing technology for vulnerable households in Tanzania** (NRI Research project R6332)
SO Food processing research in the tropics and subtropics, ECART, Bonn, 1995

TI **Socio-economic impacts of cassava postharvest technologies on smallholdings in south east Nigeria** (ID: 5725)
IA Institut fuer Agrar- und Sozialoekonomie in den Tropen und Subtropen der Universitaet Hohenheim, Fachgebiet Landwirtschaftliche Betriebslehre in den Tropen und Subtropen
CO W. Doppler

TI **The social context of technology choice: a case study of cassava processing in Sierra Leone,** NRI/Univ. of London, project R6046
CO A. Blanshard, B. Sharpe (Dept Anthropology); A. Martin (NRI)
SO Food processing research in the tropics and subtropics, ECART, Bonn, 1995

TI **Field testing and implementation of improved cassava flour production process technologies (ID: 5765)**
IA Overseas Development Administration (NRRD)
CO Mr W.H. Timmins, Natural Resources Institute
Dr R. Best/Dr. C. Wheatley, Centro Internacional de Agricultura Tropical (CIAT)

TI **Small-scale cassava starch extraction and storage to improve process efficiency,** NRI Research project R6316
SO Food processing research in the tropics and subtropics, ECART, Bonn, 1995

TI **Detoxification of cassava at household level in rural Africa** (ID: 5659)
IA WAU (Wageningen Agricultural University)
CO Wageningen Agricultural University, Ir S. Essers

TI **Biochemistry and physiology of cyanogenesis in cassava** (ID: 1798)
IA Overseas Development Administration (NRRD)
CO Dr N.H. Poulter, Natural Resources Institute

TI **Biochemistry of quality changes during storage and processing of tropical crops** (ID: 1743)
IA Overseas Development Administration (NRRD)
CO Dr N. Poulter, Natural Resources Institute
NA ....determine the influence of traditional and improved processing methods for cassava on the biochemical mechanisms and efficacies of cyanide detoxification.

TI **Studies on linamarin breakdown during processing of cassava into gari** (ID: 5290)
IA IFS
CO Ms Lucretia Barber, Dept of Food Science and Technology, Rivers State University of Science and Technology, Port Harcourt, Nigeria

TI **Lactic acid bacteria in cassava fermentation for gari production** (ID: 2901)
IA IFS
CO Ms Erinma Akpala, Dept of Microbiology, University of Nigeria, Nsukka, Nigeria
NA ...Seed cultures of the proper organisms will be made available to local products which might then be able to reduce the production time of gari.

TI **Lactic fermentation of cassava and other tropical plant crops** (ID: 1800)
IA Overseas Development Administration (NRRD)
CO Dr A. Westby, Natural Resources Institute

TI **Chemical and nutritional aspects of cassava processing** (ID: 5091)
IA Swedish Agency for Research Cooperation with Developing Countries
CO Jose da Cruz Francisco, University Eduardo Mondlane, Faculty of Engineering, Department of Chemical Engineering, Maputo
Prof. Kaare Larsson, Lund University, Department of Food Technology, S-221 00 Lund

TI **Extent of removal of cyanogenetic glycosides from cassava *Manihot esculenta* processed by traditional Kenyan techniques** (ID: 3196)
IA IFS
CO Dr J.K. Imungi, Department of Food Technology and Nutrition, Faculty of Agriculture, University of Nairobi, Kenya

TI **Studies in the chemical composition of cassava (ID: 3251)**
IA International Foundation for Science
CO Dr John Saka, Department of Chemistry, Chancellor College, University of Malawi, PO Box 280, Zomba, Malawi

TI **The development and evaluation of a new process line for gari production (ID: 5197 and 3252)**
IA IFS
CO Dr Obafemi Ajibola, Dept of Agric. Engineering, Obafemi Awolowo University, Ile Ife, Nigeria

TI **Studies on the fermentation production of Iafun and *fufu* from cassava and their storage (ID: 3215)**
IA IFS
CO Dr O. Oyewole, Dept Food Technology, University of Agriculture, Abeokuta, Nigeria

TI **Protein and vitamin-fortification studies of fermented and unfermented maize and cassava foods (ID: 3216)**
IA IFS
CO Dr T. Sokari, Dept of Biological Sciences, Rivers State University of Science and Technology, Port Harcourt, Nigeria

TI **An evaluation of traditional fermentation methods and their effects on the chemical composition of cassava-based products (ID: 5449)**
IA International Foundation for Science
CO Dr Tom Agbor-Egbe, Food Studies Laboratory, Centre for Nutrition, Institute of Medical Research and the Study of Medicinal Plants (IMPM), PO Box 6163, Yaounde, Cameroon

TI **Post-harvest technology of root and tuber crops: cassava fermentation (ID: 2902)**
IA IFS
CO Mr Festus Numfor, Centre de Recherches Agronomiques, Institut de la Recherche Agronomique, (IRA), BP 13, Nyombe, Cameroon

TI **Studies and realization of polyvalent solar dryers. ID: 3188)**
IA IFS
CO Mr Josoa Randriamorasata, Etablissement d'Enseignement Superieur Polytechnique, Universite d'Antananarivo, BP 1500, CP 101, Antananarivo, Madagascar

TI **Cassava Network [Reseau Manioc] (ID: 2084)**
TI Reseau Manioc – Amelioration des aliments fermentes a base de manioc (ID: 3759)
TI Reseau Manioc – Amelioration des mecanismes de detoxication (ID: 3758)
IA Conference des Responsables de Recherche Agronomique Africains et Français
FU Dr Joseph Mabanza, Coordonnateur du Reseau Manioc, DGRST-ORSTOM, BP 181, Brazzaville, Congo, Tel: (1 9 242) 81 26 80, 81 26 81, 81 26 82, Telex: (0981) 5404 (Attn. ORSTOM), Fax: (242) 83 22 05
Mr Guy Hainnaux, Correspondant pour la France, ORSTOM

TI **Utilization of local flours for bread-making (ID: 2881)**
IA Commission of the European Communities
CO Mr Festus A. Numfor (Georges Tiky Mpondo), Institut de la Recherche Agronomique (IRA), BP 2123, Yaoundé, Cameroun

Other root crops

TI **Collaborative programme with CIP to identify and respond to the needs of the post-harvest sector for sweet potatoes in East Africa (Research Programme)**
CO R. Bancroft (NRI, UK)
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **Development of a vitamin a-rich weaning food and child cereal from dried and "instantized" sweet potato buds. Final report**
AU Barrows, J.; Solomons, N.; Bulux, J.; Lopez, Y.; Portocarrero, L. de; Serrano, J.Q. de
AD International Eye Foundation (IEF), Bethesda, Maryland, USA
SO 1992, 164 pp.; Oct, figs, photos, tables

TI **Processing of the trifoliate yam (*Dioscorea dumetorum*) into flour with low swelling capacity for the preparation of weaning gruel (ID: 5285)**
IA International Foundation for Science
CO Dr Israel Mbome, Centre of Nutrition, Institute of Medical Research and Medical Plant Studies, PO Box 6163, Yaoundé, Cameroon

TI **Etude de certains aspects de la filière ignamne en Afrique de l'Ouest**
Projet 1995/70/CER/207, CIRAD-CA 1 Transformation en cossettes, 2 Réseaux et commercialisation
CO R. Dumont
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **Physiological basis for storage life extension in fresh sweet potato, NRI project R6319**
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

DISSEMINATION OF TECHNOLOGY

TI **Technology Applications (Zimbabwe) (ID: 5823)**
IA International Development Research Centre
CO Mr Tungamirai Rukuni, University of Zimbabwe, PO Box MP 167, Mount Pleasant, Harare, Zimbabwe

TI **Enhancement of local awareness of factors relevant to cassava processing and toxicity in Tanzania (ID: 5771)**
IA Overseas Development Administration (NRRD)
CO Dr Z. Bainbridge, Natural Resources Institute

TI **Valorisation des ressources agro-alimentaires Projet 1995/65/P3/93 CIRAD-SAR**
(Identification des ressources techniques locales et valorisation des savoir faire (Muchnik)
CO Sautier, D.
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **Organisation des entreprises agro-alimentaires, valorisation des savoir-faire locaux et innovations agro-alimentaires,** Projet 1995/65/ISAA/209 CIRAD-SAR
AB ...Produits attendus: Études et recherche/action, méthodes et outils de diagnostic et d'appui aux entreprises agro-alimentaires...
CO J. Muchnik
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **Development and Promotion of Appropriate Tools and Implements for the Agricultural and Food-Processing Sectors,** operational phase FIT-2 (ID: 6408 SIS/SPAAR)
IA ILO/TOOL
CO ILO, Geneva, Switzerland

FURTHER RESEARCH

TI **The present status of small- and medium-scale food processing** enterprises in Africa
TI **<Document Title> (Publication), United Nations Industrial Development Organization**
AU Aref., M. M.
PY – 1986 IS – No. PC.149 PG – 34pp.
AB ...Basic constraints to the development of African small- and medium-scale enterprises, including those dealing with food processing, are discussed, and some measures for their rehabilitation are proposed. As a first step in the preparation of the paper, a questionnaire was developed and sent to 34 African countries...

TI **Applications of biotechnology to traditional fermented foods: report of an ad hoc panel of the board on science and technology for international development**
AD Office of International Affairs, National Research Council, Washington DC, USA
SO Washington DC (USA), National Academy Press, 1992, 206 pp., figs, tables; bibliography (vp.)

TI **Regional post production food loss reduction and food processing – Phases I and II (ID: 3981)**
IA Southern African Development Community (SADC)/Food Security Technical and Administrative Unit (FSTAU)
CO Food Security Technical and Administrative Unit (FSTAU), SADC, Botswana

TI **Food, nutrition security and environment (ID: 4391)**
IA University of Oslo/Norwegian Institute of Agricultural Economics, Oslo
CO University of Oslo, Institute for Nutrition Research (Institutt for ernaeringsforskning), PO Box 1046, Blindern, N-0316 Oslo 3, Norway
Norwegian Institute of Agricultural Economics (Norsk institutt for landbruksokonomisk forskning, Oslo), PO Box 8024 Dep, N-0030 Oslo 1, Norway
NA This multidisciplinary and cross cultural project aims to study strategies which villagers have developed to secure a proper food and nutrition situation for households and how these strategies are taken account of by official policy workers and in development projects. Data will be collected on traditional and modern knowledge of women and men that is relevant for food production, preparation and storage as well as distribution of food within the household.

TI **Bio-Emballages, Projet 1995/65/GTAA/79, CIRAD/SAR**
CO Gontard N.
AB ...réduire les importations de matières premières d'emballages et valoriser les produits locaux, proposer des technologies de fabrication applicables à petite échelle...
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **The application of Hazard Assessment Critical Control Point Methods to food production utilization systems, NRI Project (A0452)**
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **Dynamics of marketing systems in agriculture in the course of socio-economic development, Research project Instüt für Agrarpolitik, Marktlehre, Humbold Univ, Berlin**
CO G. Lorenzl
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **Efficiency assessment of marketing systems for staples: potatoes and grain (ID: 1489)**
IA TU Berlin
CO Institut fuer Sozialoekonomie und Agrarentwicklung, TU Berlin, Podbielskiallee 64, D-1000 Berlin 33, Federal Republic of Germany, Tel: (0)30/314 71311

TI **Marché, institutions et rôle de l'Etat dans l'agriculture**
CO M. Griffon, CIRAD-URPA
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **Market opportunities for primary products (starches and flours) identified and technical options tested and promoted in sub-Saharan Africa, NRI project R6315**
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **Concepts for improved integration of agriculture and agroindustry, GTZ project 93.2115.9**
AB Objective: improve vertical integration between agricultural producers or their self-help organisations and agroindustry
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **Promotion des petits entreprises agro-alimentaires,** Projet CIRAD-SAR 1995/65/P3/92 (Appui à l'artisanat et aux PME agro-alimentaires et Etude du fonctionnement des entreprises)
CO B. Bridier, J. Muchnik
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **Artisanat alimentaire au Benin (ID: 4595)**
CO Mr Jose Muchnick, CIRAD-CEEMAT

TI **Consommation alimentaire urbaine et promotion des produits locaux,** Projet 1995/65/P3/91, CIRAD-SAR
AB ...2 Analyse de la structuration de secteurs agro-alimentaires (Bricas-Muchnik)
CO N. Bricas
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **Promotion of the processing of agricultural products,** GTZ 90.2183.3
TI **Promotion of small-scale rural agroindustries,** GTZ 92.2121.9
NA (short description by author) The two projects might provide interesting experiences. In Indonesia (GTZ 90.2183.3) a concept is developed for the transfer to other regions. In Thailand (GTZ 92.2121.9) a promotion concept for small agro-industrial companies is developed. The projects were executed from 1991 to 1995 and from 1993 to 1996, respectively.
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995

TI **Developing marketing and credit opportunities for small-scale producers in semi-arid production systems,** NRI project R6344
SO Food processing research and development in the tropics and subtropics, ECART, Bonn, 1995
Publ. available from this project

TI **Pilotage de l'innovation dans les filieres courtes (ID: 4591)**
CO Mr Nicolas Bricas, CIRAD-CEEMAT

TI **Procedes combines de stabilisation et de texturation (ID: 4596)**
CO Mr Stephane Guilbert, CIRAD-CEEMAT

TI **Report on operational programmes: 1989–91. 1 January 1989 – 31 March 1991**
AD Natural Resources Inst., Chatham, Kent, UK
SO 1991, unnumbered, 342 pp., figs, photos, tables

TI **Effects of processing on distribution and destruction of mycotoxins (ID: 4737)**
IA Overseas Development Administration (NRRD)
CO Dr B.D. Jones, Natural Resources Institute

TI **Irradiation to curb food losses**
AU Nwasi, J.
CS All Africa Press Service, PO Box 14205, Nairobi, Kenya
PU Science and Technology Features Service, All Africa Press Service, Nairobi
PY 1985 PG – 3pp.
AB ...The Dakar-based African Regional Centre for Technology (ARCT) holds the view that food preservation by irradiation can play a major role in solving Africa's acute food loss problems. Despite the promise that the irradiation technique holds for Africa's food problems, its application on a significant scale may be impaired by financial constraints and lack of resources. The generalization of this technique in Africa depends therefore on futher scientific research for its economic feasibility.

TI **Co-ordinated research programme on the application of irradiation technique for food processing in Africa** (ID: 2629 SIS/SPAAR)
IA FAO

TI **[Small-scale food processing and fuelwood consumption]**
AU Laura, P.
PU Paris (France) PU - Altersyal PY – 1992 (ID: CAB 472)

ABBREVIATIONS

Fields in project records

TI	title
IA	implementing agency
CO	contact
FU	funding establishment
NA	narrative (only those parts that relate to the subject of this study report are included here)

Fields in abstracts of publications

TI	title (in brackets when the publication is not in English; in these cases the title in the original language is provided under OT)
OT	original title
AU	author
AD	address
SO	source
PU	publisher
AB	abstract (only those parts that relate to the subject of this study report are included here)

Databases used for research and development projects

SIS	Special Program for African Agricultural Research (SPAAR) Information System
ECART	Food Processing Research and Development in the Tropics and Subtropics, Documentation on Research Development Activities of European Institutions

Databases used for literature

CAB Abstracts	CAB International
TROPAG	Tropical Agriculture and Rural Development Abstracts, Royal Tropical Institute (KIT)
AGRIS	FAO
AGRICOLA	US Department of Agriculture
FSTA	Food Science and Technology Abstracts, IFIS Publishing

ANNEXE 3

Experts consulted during the study

Centre for African Studies, Leiden, The Netherlands
Laurens van der Laan (economics)

CIRAD, Montpellier, France
Département des systèmes agroalimentaires et ruraux (CIRAD-SAR):
Nicolas Bricas
José Muchnik
Nadine Zakhia
Bernard Bridier
Francis Troude
Département des cultures annuelles (CIRAD-CA):
Jaques Faure
Christian Mestres
Michel Havard

IMAG/DLO, Wageningen, The Netherlands
Ad Wanders (agricultural engineering)

ITDG, Rugby, UK
Ann Watts (publications)
Robert Spencer (question and answer service)
Ishmael Sunga (small enterprise development)
Mike Battcock (social science and policy)
Sue Brough (social science and policy)
Barrie Axtell (food dehydration and oil processing)

Leiden University, Leiden, The Netherlands
Caroline Jongkamp (cereal banks)

Midway Technology, Woodford Hals, Northants, UK
Peter Fellows (small enterprise development and training)

NRI, Chatham, UK

R. Guy Poulter (Head, Crop Utilization Dept.)
Andrew Westby (Head, Root and Tuber Crops Group)
Paul Hindmarch (Deputy Head, Food Security Dept.)
Tony Swetman (agro-processing)
Karin Wellings (agro-processing)
Debby Jones (agro-processing)
Linda Hammond (agro-processing)
Richard Marder (agro-processing)
Andrew Hall (social science and technology policy)
Adrienne Martin (socio-economics)
Peter Golob (storage)
Rachel Stringfellow (economics)
John Coulter (economics)
Ulrich Kleih (marketing)
Roger Bancroft (root crop storage and processing)

Koninklijk Instituut voor de Tropen (Royal Tropical Institute), Amsterdam, The Netherlands

Han van de Meerendonk (economics/marketing)
Willem Würdemann (food processing/ management)

TOOL Foundation, Amsterdam, The Netherlands

Frans Korthals-Altes (food processing)

Wageningen Agricultural University, Wageningen, The Netherlands

Sander Essers (cassava detoxification)
Robert Nout (food fermentation)
Peter Zuurbier (chain management)
Aad van Tilburg (marketing)
Otto Hospes (rural credit)

Acronyms and abbreviations

ACCT	Agence de coopération culturelle et technique (France)
ACP	African, Caribbean and Pacific
AGRICOLA	Agricultural On-Line Access
AGRIS	Agricultural Information System (FAO)
ATI	Appropriate Technology International
ATO	Agro-Technological Research Institute (Netherlands)
ATSAF	Arbeitsgemeinschaft Tropische und Subtropische Agrarforschung
AUPELF	Association des universités partiellement ou entièrement de langue française
CABI	Centre for Agriculture and Biosciences International (UK)
CCT	Christian Council of Tanzania
CEEMAT	Centre d'études et d'expérimentation du machinisme agricole tropical
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIDA	Canadian International Development Agency
CILSS	Comité permanent inter-Etats de lutte contre la sécheresse dans le Sahel
CIP	Centro Internacional de la Papa
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
CIRAD-CA	Département des cultures annuelles (CIRAD)
CIRAD-SAR	Département des systèmes agroalimentaires et ruraux (CIRAD)
CMDT	Compagnie Malienne pour le Développement des Textiles
CNEARC	Centre National d'Etudes Agronomiques des Régions Chaudes
CNRA	Centre national de recherches agronomiques (Senegal)
CORAF	Conference des responsables de recherche agronomique africains
COSCA	Collaborative Study of Cassava in Africa
CRAT	Centre régional africain de technologie (Senegal)
CTA	Technical Centre for Agricultural and Rural Cooperation (ACP-EU)
DFID	Department for International Development (UK)
DLS	diffused light storage
DSE	Deutsche Stiftung für Internationale Entwicklung
ECART	European Consortium for Agricultural Research in the Tropics
ENDA	Environnement et développement du tiers-monde
ETC	Foundation for Ecology, Technology and Culture
EU	European Union
FACE	Farmers' Analysis-Choice-Experiment
FAKT	Fördergesellschaft für Angepasste Techniken
FAO	Food and Agriculture Organisation of the United Nations
FCE	farmer-controlled enterprise
FIT	Farm Implements and Tools programme
FSTA	Food Science and Technology Abstracts
GASGA	Groupe d'assistance aux systèmes concernant les grains après récolte
GATE	German Appropriate Technology Exchange

GRAF	Groupe de Recherche-Action-Formation
GRATIS	Ghana Regional Appropriate Technology Industrial Service
GRET	Groupe de recherche et d'échanges technologiques
GTZ	Gesellschaft für Technische Zusammenarbeit
HACCP	Hazard Analysis Critical Control Point
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDESSA	Institut de savanes
IDRC	International Development Research Centre
IEF	International Eye Foundation
IER	Institut d'économie rurale (Mali)
IFAD	International Fund for Agricultural Development
IFS	International Foundation for Science
IITA	International Institute of Tropical Agriculture
ILO	International Labor Organisation
IMAG	Institute for Agricultural Mechanisation
IRA	Institut de la Recherche Agronomique (Cameroon)
IRRI	International Rice Research Institute
ISRA	Institut sénégalaise recherches agricoles
ISTRC	International Society for Tropical Root Crops
IT	Intermediate Technology
ITA	Institut de Technologie alimentaire (Senegal)
ITDG	Intermediate Technology Development Group
ITTU	Intermediate Technology Transfer Unit (Ghana)
KIT	Koninklijk Instituut voor de Tropen (Royal Institute for the Tropics) (Netherlands)
NARO	National Agricultural Research Organisation (Uganda)
NAS	National Academy of Science (USA)
NGO	Non-government organisation
NRC	National Research Council (USA)
NRI	Natural Resources Institute (UK)
NRRD	Natural Resources Research and Development (DFID)
OAU-STRC	Organisation of African Unity – Scientific and Technical Research Commission
ODA	Overseas Development Administration (now DFID)
ORSTOM	Institut français de recherche scientifique pour le développement en coopération
PTD	Participatory Technology Development
PUDOC	Centrum voor landbouwpublikaties en landvouwdocumentatie
RATIS	Regional Appropriate Technology Information Service
RESAA	Réseau sur la transformation des produits agroalimentaires
RMA	Rapid market appraisal
RRA	Rapid rural appraisal
SACCAR	Southern African Centre for Cooperation in Agricultural Research
SADC	Southern African Development Community
SAED	Société d'aménagement et d'exploitation des terres du delta
SAFGRAD	Semi-Arid Food Grain Research and Development
SIATA	Service inter-africain de technologies appropriées
SIS	SPAAR Information System
SODEFITEX	Société pour le Développement de la Filière de Textile
SPAAR	Special Program for African Agricultural Research

TDRI	Tropical Development and Research Institute
TOOL	Technologie Overdracht Ontwikkelings Landen
TPA	Réseau technologie et partenariat en agroalimentaire
UMA	Uganda Manufacturers Association
UNIDO	United Nations Industrial Development Organisation
UNIFEM	United Nations Development Fund for Women
USAID	United States Agency for International Development
WFP	World Food Programme
WHO	World Health Organisation