

# **CROP POST HARVEST PROGRAMME**

**Development of new market opportunities, to increase the contribution that cassava makes to sustainable rural livelihoods**

**R7418 (ZB0165)**

## **PROJECT EVALUATION REPORT**

**1 July 1999 – 30 June 2002**

Dr A. Graffham Natural Resources Institute – Project Manager  
Mr N. Dziedzoave Food Research Institute – National Co-ordinator  
Mr E. Boateng National Board for Small Scale Industries Deputy Nat Co-ordinator  
Professor G. S. Ayernor University of Ghana – Project Leader  
Dr N. Darkwa Forestry Research Institute of Ghana – Project Leader  
Mr L. Krampa Ministry of Food and Agriculture (Brong Ahafo) – Project Leader

## CONTENTS

	Page
<b>Section A</b> <b>Executive Summary</b>	1
<b>Section B</b> <b>Project Background</b>	2
<b>Section C</b> <b>Evaluation of the identification and design stage</b>	2
<b>Section D</b> <b>Evaluation of the implementation process</b>	4
<b>Section E</b> <b>Evaluation of project activities</b>	6
<b>Section F</b> <b>Evaluation of Project effectiveness</b>	22
<b>Project Purpose</b>	22
<b>Project Outputs</b>	22
<b>ANNEXES</b>	25
I      Project Logical Framework	28
II     Results of end of project workshop	29
III    Workplan for adoption of project outputs	41
IV    Feedback on the project from managing & non-managing partners	42
V     List of publications	47
VI    Catalogue of data sets with location	47

## **Section A Executive Summary**

The purpose of this project was to contribute towards improved sustainable livelihoods, and better levels of income for cassava farmers and processors in rural areas by expanding the range of market opportunities available for cassava –based products, and promoting use of cassava by industry. The outcomes of project R7418, include delivery of validated cost effective technologies for production of high quality cassava flour for use in selected bakery products and plywood glue, sugar syrups for food use, industrial alcohol for the chemical industry and a complete paperboard adhesive for the cardboard packaging industry.

In the production areas in Atebubu District, the cassava flour processors groups in Watro and Kokofu villages have increased in size from 22 to 60 members (85% women). One group has become self-sustaining with orders coming in from bakers in a nearby town, and a large food processor in Accra. A recent order was worth \$2000, allowing many of the processors to open bank accounts and to spend sums ranging from \$100 to \$150 on their families using income derived from cassava flour. Given that village income levels are <\$500 per annum in many cases, cassava flour represents a significant boost to household income. A private sector investor has established an intermediate processing plant for cassava-based products near to Accra and the project team have identified some 20 industries in the food, paperboard, plywood and chemical sectors around Accra, Tema, Kumasi, Sekondi-Takoradi, Sunyani and Berekum who are interested to buy locally produced cassava-based products. Many of these industries have been involved in project activities (industrial trials) and some have formed links with the intermediate processor. One paperboard manufacturer has started to manufacture cassava-based adhesive using technology developed under project R7418. A combination of industrial trials, training sessions, brochures and manuals, promotional seminars, trade fairs and agricultural shows and media coverage on television and radio and in newspapers has resulted in a steady increase in interest in cassava for non-traditional purposes in Ghana. Awareness seminars conducted by NBSSI attracted 189 participants, and over 100 follow-up enquiries have been received by NBSSI, FRI, MoFA and FORIG. The dissemination strategy of project R7418 has been augmented by integration into the IFAD funded Root and Tuber Improvement Programme, the national business advisory programme of NBSSI, and through circulation of project outputs to IITA in Ibadan and Kampala.

Projects R7418 and R6504 dealt with strategic and adaptive issues to prepare the way for uptake of cassava as an industrial commodity. For this reason impact on rural livelihoods was comparatively limited. However, it is clear that conditions are favourable for the uptake of cassava as an industrial commodity. A new project been developed (R8268) that will complete the process by providing: (i). cassava farmers and primary processors with micro-finance and technical back-up, (ii). three intermediate processing factories with financial support for industrial trials and technical support for manufacture of cassava-based products, (iii). technical support for users of cassava-based products, and (iv). act as a mediator within the market system.

## Section B Project Background

### B.1 Administrative data

Period under report: 1/7/1999 – 30/11/2002	Project Leader/Institution: Dr A Graffham, Natural Resources Institute
NRIL Contract Number: ZB0165	Collaborating institution(s) Food Research Institute Forestry Research Institute of Ghana Ministry of Food and Agriculture (Brong Ahafo) National Board for Small-Scale Industries University of Ghana (Dept of Nutrition and Food Science)
DFID Contract Number: R7418	<b>Target Institution(s)</b> Government Institutions – Food Research Institute, Forestry Research Institute of Ghana, Ministry of Food and Agriculture – Brong Ahafo, National Board for Small Scale Industries, University of Ghana <b>NGO</b> – Technoserve, APED <b>Private Sector</b> – Atebubu Bakers Association, Watro and Kokofu Processing groups, Logs and Lumber Limited, Polykraft Limited, Pakrite Limited, Amaasa Agroprocessing Company, Lumber Processing Limited, Wordsworthy Press, Kul Industrial Alcohol Limited
Project Title: Development of new market opportunities, to increase the contribution that cassava makes to sustainable rural livelihoods	Start Date: 1/7/1999 End Date: 30/6/02
Research Programme: Crop Post Harvest	Budget (i.e. Total Cost): £309,190
Production System: Forest/Agriculture Interface	

## Section C Evaluating the identification and design stage

The national annual estimated value of cassava harvested is 106.2 billion\* Cedis, however only 21.3 billion\* Cedis is realised from sales (GSS, 2000). The corresponding figures for the Brong Ahafo Region are 64.4 and 2.4 billion\* Cedis respectively. The estimated cassava surplus for 2001 after making allowances for consumption is 3.5 million metric tonnes that accounts for 38% of national production (SRID/MOFA, 2001; Quaye *et al.*, 2002). Processing of cassava is limited to traditional technologies like *gari*, *kokonte*, *agbelima*, *tapioca*, and minimal amounts of low-grade starch and starch biscuits (Dziedzoave *et al.*, 1996) Farmers' concerns to expand market opportunities for cassava and improve producer prices have been highlighted (Kleih *et al.*, 1994). The existence of market opportunities in Ghana have also been amply demonstrated (Day *et al.*, 1996; Graffham *et al.*, 1998). The key livelihood constraints identified by Kleih *et al.*, (1994) and Day *et al.*, (1996) were:

- Lack of access to markets for fresh cassava.
- Unreliability of existing markets
- Inability to access existing potential markets
- Unavailability of appropriate technologies and technical know-how to meet the demands of existing potential markets.
- High production costs and low profit margins on food products

- Over-reliance on imported materials and depletion of foreign exchange reserves
- High unemployment rates especially during off-peak farming seasons.
- Absence of a conducive policy environment for industrial utilisation of cassava products.

In the early stages of development of the first cassava markets project (R6504), Brong Ahafo Region and Atebubu & Seni Districts in particular were identified as being most promising as supply areas of cassava for industrial purposes, on the basis of data from production versus sales and consumption. These figures indicated that significant in-ground surpluses of cassava existed in these areas, and that farmers in the area were operating at levels well below the poverty line. Subsequent discussions with farmers in Atebubu District (Brong Ahafo) confirmed farmers' interests in improving income by accessing alternative markets for cassava.

The annual per capita income for the Brong Ahafo region is ₵548,000.00 (£46) which is below the average poverty line of ₵900,000 (£75), and the extreme poverty line of ₵700,000.00 (£58) per annum (Ashong and Smith, 2001; GSS, 2000). The extreme poverty gap in Ghana is estimated to be 31% (<http://www.worldbank.org/participation/ghanacase.htm>). The poverty incidence for the rural forest zone in Ghana is 38 whilst that for the Brong Ahafo in particular is 36. In general food crop farmers have a poverty incidence of 59, whilst non-food self-employed groups like the small-scale end-users have a poverty incidence of 29 (GSS, 2000). According to the Ghana Living Standards Survey (GSS, 1995), about 30% of rural households have no access to potable water, whilst about 66% have no access to a place of convenience, and 70-80% do not have easy access to good medical facilities. The groups targeted under projects R6504 and R7418 are mostly rural farmers and processors and fall within the poverty groupings described above.

Project R6504 focussed on dealing with the most important strategic areas of research working in close collaboration with representatives of the plywood, paperboard and bakery industries (as target institutions for cassava-based products). The initial team comprised of Natural Resources Institute, Food Research Institute and University of Ghana (Dept of Nutrition and Food Science) who formed a partnership (and management team) to work mainly on use of high quality cassava flour in food products. As the work evolved the Forestry Research Institute of Ghana and Ministry of Food and Agriculture (Brong Ahafo) became involved in the work to cover industrial adhesives and adaptive research with farmers in Atebubu District respectively. FORIG and MoFA were not involved in the management of R6504.

The outcomes of project R6504 showed the potential for alternative markets for cassava and opportunity for improving incomes and livelihoods for farmers and primary processors. The need for more adaptive research and strategic research at various points in the system, and importance of raising awareness of alternative markets for cassava more widely were also highlighted. In developing project R7418 the project team was expanded to include FORIG and MoFA, and the national Board for Small Scale Industries (NBSSI) was approached as a possible partner for awareness and dissemination activities. NBSSI agreed to join the team to lead the dissemination side of the project, and to look at the commercial viability of expanded markets for cassava through cost benefit analyses and development of business plans. Links with farmers, rural bakers and potential industrial users of cassava-based products were maintained and strengthened through meetings to discuss needs and perspectives on the work, but it was not considered appropriate at this stage to involve them formally in the management of the project.



In developing project R7418 the long-term (beyond the life of the project) roles of the partner institutions began to evolve. It was envisaged that FRI, FORIG and UoG would have a role in provision of training and technical support to the private sector in adopting cassava as an industrial commodity. MoFA would provide training and support for farmers, primary processors and bakers in rural areas and NBSSI would take the lead in helping entrepreneurs to develop business plans and access finance to take up successful outcomes of the research. NRI was envisaged as having a role as a neutral intermediary in the market system during the early stages of uptake, but would gradually be replaced by Ghanaian institutions to ensure sustainability. The identity of the Ghanaian partner had not been clarified in 1999, but it was thought that the CSIR institutes would be well placed to take on this role at the urban end of the system. MoFA were well placed to deal with matters involving production and primary processing.

### **Section D Evaluating the implementation process**

Project R6504 started as a conventional CPHP research project with a single project leader lead institution and two collaborating institution, with all responsibility and managerial power vested in the project leader at the lead institution. However, in 1997 a change in project leadership at the lead institution created the opportunity to develop an improved approach to project management. This approach consisted of forming a project team of core partners (known within the project as managing partners), with links to target institutions (non-managing partners). Thus the cassava project team started to evolve a partnership approach to project management some 5 years before the CPHP announced their innovations partnerships strategy. The new approach proved successful but several weaknesses were identified. Most notably, it was clear that overall leadership is required, but NRI was not well placed to control the project on a day to day basis due to not being based in Ghana.

In project R7418, the approach started under R6504 was improved to create an effective management team. The management team for R7418 consisted of six managing or core partners. The team selected NRI as the overall project co-ordinator, FRI as national co-ordinator and NBSSI as deputy national co-ordinator and co-ordinator for dissemination. Management decisions on direction and major changes to the project were vested with the management team, but the co-ordinating partners were charged with the role of mediation and overall leadership, and were given the power collectively to make the final decision in the event of a lack of consensus.

**NRI as overall co-ordinator** had the following roles and responsibilities:

- Financial control (through sub-contracts with other partners)
- Contractual responsibility (to CPHP) for delivery of the project
- Preparation and submission of project management reports on behalf of the team
- Liaison with CPHP head office in the UK

**FRI as national co-ordinator** had the following roles and responsibilities:

- Liaison with all partners in Ghana on technical matters and management reporting to NRI.
- Liaison with CPHP regional office in Accra

**NBSSI as deputy national co-ordinator** and dissemination co-ordinator had the same role and responsibilities as FRI in the absence of the national co-ordinator, but in addition were responsible for organising dissemination and awareness activities and co-ordinating with groups of partners in the preparation of presentations and training manuals and guides derived from project activities.

Each one of the six managing partners, developed and implemented their own activities within the project framework agreed by the team. Each institution had its own independent budget line (developed by the institution at the PMF stage of the project development process) to fund project activities, and a project leader to act as a point of contact, and take responsibility for delivery of project activities on behalf of his/her institution.

Management reporting was set-up along the lines required by DFID with each managing partner to provide quarterly reports to the overall co-ordinator. The overall co-ordinator then prepared composite quarter reports for submission to the CPHP.

Co-ordination meetings of the whole team were held at least twice per year with the key meeting being held in March of each year for the team to prepare the annual report of the project. Annual reports were signed off by each institution before submission to CPHP.

Towards the end of the project (June 2002), a special co-ordination meeting was held to discuss preparation of the PCSS and PER. NRI as overall co-ordinator prepared the PCSS and final version of the PER by combining individual reports of progress prepared by each partner for the PER meeting.

The non-managing/peripheral partners and linkages to the project were as follows:

**Kokofu and Watro Cassava Processing Groups** – Contact with the cassava farmers and primary processors in Watro and Kokofu was maintained through the MoFA extension officers for each village. Staff from MoFA (Sunyani), FRI and NRI made several visits each year to discuss progress and address issues raised by the villagers (see below).

**Atebubu Bakers Association** – Contact was established with the President of the association Mrs Wilson. Mrs Wilson has acted as a main point of contact for working with rural bakers in Atebubu and Seni Districts, and has also worked for the project as a trainer and needs assessor, and took the lead in writing a recipe book of bakery products containing cassava flour.

**Bakers in Yeji, Kwame-Danso, Amantin and Prang** – MoFA in collaboration with Mrs Wilson a baker from the Atebubu Bakers Association responded to requests for support from bakers in towns in Atebubu and Seni Districts by making an assessment of the needs of the bakers and then providing practical training in the use of cassava flour. MoFA is maintaining links with rural bakers via local extension agents and the bakers associations in each town.

**Plywood factories in Kumasi, Sekondi-Takoradi, Berekum and Sunyani and Paperboard factories in Tema and Sekondi-Takoradi** – Contact with each factory has been on an individual basis. The majority of contact being with staff from FORIG, but with some inputs from staff at FRI and NRI.

**Root and Tuber Improvement Programme** – The project team have linked with the IFAD funded RTIP programme both directly and via the RTIP co-ordinator at FRI. Staff from FRI and NRI have made presentations at RTIP farmers meetings in Sunyani and Kumasi, and held strategic discussions with the RTIP secretariat in Kumasi. RTIP have taken forwards the HQCF technology with a national awareness campaign and have formed links with bakers in Nsawam to use cassava flour in bread.

**International Institute for Tropical Agriculture (Kampala)** – Between 1999 and 2000 NRI worked with IITA and the Ugandan Government (NARO) to transfer techniques and expertise on expanded markets for cassava (developed in Ghana) to Uganda. Copies of reports from projects R6504 and R7418 were provided to IITA and NARO and staff from both institutes were trained in market based techno-economic approach developed by the team in Ghana.

**Crop Post Harvest Programme** – Links were maintained with the CPHP through formal management reports, and informal meeting and discussions between the project leaders at NRI and FRI with the Regional Co-ordinator and the Programme Manager during visits of the national co-ordinator to the United Kingdom.

The approach taken by R7418 remained largely unchanged during the life of the project, but various weaknesses and limitation to the existing systems were identified, that taken into consideration in developing the follow on project (R8268). At the rural end of the production system discussions with farmers and primary processors revealed problems with financial support, independent mediation and limitations of the projects monitoring system at village level. It became clear that farmers and primary processors require micro-finance and a support organisation that would monitor activity in the village on a weekly basis and mediate in the event of internal disputes with the group, or problems between the farmers and purchasers of cassava and cassava-based products. For this reason an NGO (APED) was identified with the capacity to take on the role identified by the farmers.

At the urban end of the market system, the absence of a medium-scale intermediary processor was seen as the key weakness. It was also clear to the project team that any future project should bring representatives of the private sector into the management team as full partners in the project from the earliest stages in the proposal development process. During the life of project R7418 over a 100 enquiries were received from private sector organisations interested in cassava, and about 20 were considered serious enough to involve in discussions at the PCN stage of the proposal development process for the new cassava project (R8268). After discussion of financial commitments only three prospective private sector partners remained. Two were incorporated into the project coalition, and the third is represented through associations with APED.

## **Section E      Evaluating your activities**

### **Output 1: Potential for cassava-based syrups assessed and procedures for conversion of cassava to sugars and industrial alcohol's developed.**

#### **Summary of achievements**

Strategic and adaptive research in Ghana, has shown that cassava flour can be used to produce a high clarity maltodextrin syrup using enzymes derived from fresh or dried seedlings of selected Ghanaian varieties of rice or maize. The final DE of the syrup will normally be in the range from 38-42, but simple process control measures can be used to vary the final DE to meet the end users specifications. An assessment of the economic feasibility of sugar syrup production from cassava flour, determined that cassava flour-based sugar syrup should be economically viable as a replacement for imported sugar syrups, but not cane sugar (under current conditions).

As a result of the collapse of the major distiller in Ghana early in the project, work on industrial alcohol was reduced to a low level and replaced with more extensive work on



cassava flour in bakery products. However, a survey of market potential for industrial alcohol showed considerable potential for replacement of imported industrial alcohol.

Cassava flour can be used to substitute for up to 30% of wheat flour in bread, 40% in biscuits and 100% in cake without adverse consumer responses. Bakers found the cassava flour acceptable but recipes normally required modification to allow for the different properties of cassava flour, and although cassava flour was found to have good shelf-life characteristics in the pure state, bread made with 30% cassava flour developed mould within 3-4 days (as compared to 7 days for bread made from 100% wheat flour). Bakers were able to cope with the reduced shelf-life by careful planning to avoid surplus production. A cost benefit analysis of 18 bakery products prepared by bakers determined that profits increased for 11 products, but decreased dramatically for the remaining 7 when cassava flour was used as a partial substitute for wheat. Cassava flour improved profits in products where cassava flour allowed the quantities of other expensive ingredients such as sugar and margarine to be reduced. In products where these ingredients had to be increased to compensate for the reduction in gluten content caused by reducing the percentage of wheat flour, cassava flour proved uneconomic for bakers.

Work under output 1 was divided mainly between strategic research on sugar syrups (FRI, NRI & UoG) and industrial alcohol (mainly UoG) and adaptive research and support for producers and users of HQCF in Brong Ahafo (MoFA). This section has been divided along institutional lines

#### **Summary of activities carried out by FRI & NRI**

The Food Research Institute (FRI) concentrated on the main part of the strategic research into the potential for conversion of cassava flour into sugar syrup. As part of the work Mr Nanam Dziedzoave of FRI was registered for a PhD with NRI at the University of Greenwich and spent three periods of six months each carrying out research at NRI's laboratories in the United Kingdom. In addition FRI made an assessment of the economic feasibility of maltose production in Ghana.

#### **Comparative assessment of selected plant sources for amylolytic and cellulolytic activity**

A comparison of the six plant sources evaluated namely rice, millet, sorghum, maize, sweet potatoes and kudeme, shows that *kudeme* is the one with the least enzyme potential. The enzyme levels observed in *kudeme* were much lower than those from the other plant sources, and this does not make it a viable option for exploitation within the context of the current work. However the fact that three of the enzymes were not present in the fresh cassava but were detected in the *kudeme* samples suggests that if conditions are varied appropriately the level of enzymes could be increased. On the other hand all the sweet potato varieties investigated were richer in  $\beta$ -amylase than all the other plant sources. The pink-skinned varieties demonstrated the highest potential for exploitation in the production of glucose syrups. Cultivating these in the forest zone would further enhance their  $\beta$ -amylase activity and be most useful for the intended purpose of hydrolysing starchy materials. The application of nitrogen fertiliser and the use of organic manure could also possibly enhance  $\beta$ -amylase levels in growing sweet potatoes. Late harvesting is as well optimum for enzyme development.

The usefulness of the cereals lies in their  $\alpha$ -amylase, amyloglucosidase and  $\beta$ -glucanase activities. Rice malt showed the highest activity for  $\alpha$ -amylase, amyloglucosidase and limit dextrinase. Millet and sorghum malts were however richer in  $\beta$ -glucanase and gave the highest level of enzyme activity than the other two

cereals investigated. The optimum malting period was 9 days for  $\beta$ -amylase, 11 days for amyloglucosidase, limit dextrinase and  $\beta$ -glucanase, and 13 days for  $\alpha$ -amylase. It is obvious from the above results that rice, sorghum and millet, are the best cereal options for optimisation for the specified enzymes. Maize malt is however the most suitable alternative source for  $\alpha$ -amylase, in the absence of rice malts. Optimisation of the cereal malts could be achieved through the manipulation of malting conditions. The effects of steeping and germination period, air rest period during steeping, temperature of steeping and germination, growth additives, and drying temperature and time on enzyme development in the three cereals could provide useful information for optimising enzyme activity. Blends of malts from rice and sorghum/millet could provide a better complement of  $\alpha$ -amylase and  $\beta$ -glucanase for a more efficient liquefaction and dextrinisation of a fibre-containing starchy material, like cassava flour, in the production of glucose syrup than any of the two malts alone. A blend of rice malt and sweet potato flour would however be more effective for the saccharification of the liquefied starchy material to produce maltose syrup.

The observed  $\beta$ -amylase activity of the sweet potatoes were relatively high and having been assessed with respect to maturity, variety and agro-ecological zone, it is considered well optimised enough for the saccharification of cassava flour without any further optimisation. Rice and millet were therefore chosen for further optimisation with respect to variety, and other selected malting conditions to improve the enzyme activity levels of  $\alpha$ -amylase, amyloglucosidase, and limit dextrinase and  $\beta$ -glucanase.

#### **Optimising the development of amylolytic and cellulolytic enzymes in rice and millet malts**

Amongst the three rice varieties assessed TOX3108 was the most promising choice for the production of a malt that could serve as a rich source of all four amylolytic enzymes, without any treatments. The response of the different rice varieties to gibberellic acid treatment and non-matting effects were found to be enzyme specific. In general however the application of gibberellic acid and non-matting conditions of malting most effectively stimulated the production of amyloglucosidase and limit dextrinase respectively. Limit dextrinase was the only enzyme whose production was significantly enhanced by both gibberellic acid treatment and non-matting conditions of malting in all three varieties of rice studied. Variety GK88 was also the only variety for which both gibberellic acid treatment and non-matting conditions of malting enhance amyloglucosidase development. The only enzyme that was most adversely affected by both gibberellic acid treatment and non-matting conditions was  $\alpha$ -amylase. Application of KBr significantly improved  $\alpha$ -amylase activity in rice variety B189 with enzyme activity still increasing at 12 days malting period. The combined use of GA<sub>3</sub> and KBr significantly enhanced limit dextrinase activity in B189 but significantly suppressed  $\alpha$ -amylase activity.

The best drying temperature for optimum enzyme activity varied between 45°C and 50°C depending on the enzyme in question. Optimum drying time was between 12 – 24 hours. Drying at 50°C for 12 hrs could be advantageously used to obtain malts that are relatively richer in  $\alpha$ -amylase; whilst drying at 45°C for 24 hrs could be used for production of malts relatively richer in amyloglucosidase and limit dextrinase. Millet malt could be conveniently dried at 45°C for 12 hrs. These findings provide an opportunity to produce a variety of malts from the same source but with varying degrees of usefulness for the different stages of starch hydrolysis.

The principal conclusions from this study was that:

- Production of an  $\alpha$ -amylase-rich malt would be best achieved through the use of TOX3108 variety of rice malted under KBr treatment and matting conditions for at least 12 days, and dried at 50°C for 12 hrs,
- A malt with a good complement of amyloglucosidase and limit dextrinase for saccharification purposes can be best produced by malting TOX 3108 rice variety with GA<sub>3</sub> treatment under matting conditions for about 10 days and dried at 45°C for 24 hrs,
- $\beta$ -Glucanase-rich malts can be best produced from millet malts dried at 45°C for 12 hrs.
- An all round malt with a good complement of  $\alpha$ -amylase, amyloglucosidase and limit dextrinase would be best produced from TOX3108 malted with GA<sub>3</sub> application under matting conditions for 10 –11 days, and dried at 45°C for 24hrs.

The above options have been selectively employed in combination with sweet potato flour (as  $\beta$ -amylase source), to investigate how the quality of cassava flour hydrolysates varied with different proportions of rice malt, millet malt and sweet potato flour in the reaction mixture.

### **Mathematical modelling of glucose syrup production from cassava flour and plant enzymes**

In order to extend the usefulness of the conversion procedure beyond the crude conversion of cassava flour into a mixture of maltodextrin fractions, a method of controlling the hydrolytic process was required. As part of the research a mathematical model is being developed that will allow an industrial processor to control conditions sufficiently to enable a range of different sugar syrups to be produced to order. At the time of writing this model was still under development, but it will become available by March 2003.

### **Economic feasibility of maltose production in Ghana**

Sweet potatoes, rice malt and millet malts are the most important plant sources of saccharifying enzymes for glucose syrup production (Table 1). The cassava supply surplus (Table 2) is more than enough to meet the requirements for glucose syrup production (Table 5) needed to satisfy the domestic market (Table 3 & Figure 1). Profits of between 1 million to 3.3 million cedis per month could be realised from glucose syrup production depending on the scale of production.

Cash flow analysis of the alternative options for sugar syrup production revealed that cassava flour-based sugar syrup production is financially and economically viable with an estimated NPV of 3,023,264 Cedis and 85,755,097 Cedis at 30% discount rate; and IRR of 44% and 137% for small-scale and large-scale production respectively. However, sugar syrup production from starch is not financially viable due to the high cost of starch. Economically, sugar syrup cannot be substituted for sugar as a sweetener. The immediate market envisaged for centralised/commercial production option is industrial use of sugar syrup.

**Table 1. Activity of Saccharifying Enzymes From Different Plant Sources**

	Mean Enzyme Activity (Units/g)				
	Beta Amylase	Amyloglucosidase	Limit Dextrinase	Alpha Amylase	Beta Glucanase
Sweet potato	<b>353.44</b>	-	-	-	-
Sorghum	65.06	0.203	1.54	8.56	1.26
Millet	28.54	0.167	0.76	4.08	<b>1.41</b>
Rice	102.02	<b>0.262</b>	<b>4.92</b>	<b>92.04</b>	0.47
Maize	60.22	0.081	0.46	53.69	0.16
Kudeme	-	0.04	0.01	0.1	0.08

Figures in bold indicate the plant source with the highest enzyme activity level for each enzyme.

**Table 2. Cassava Supply/Demand in "000 MT" (1995-2001)**

Year	Production in Brong Ahafo Region	Total National Production	Total Non Food Use <sup>3</sup>	Net Domestic Food Production/Total domestic Supply	Total Consumption Requirements	Food balance (deficit/Surplus)
1995	1347	6612	1983.6	4628.4	2609.271	2019.129
1996	1468.5	7111	2133.3	4977.7	2669.151	2308.549
1997	1425.6	7150	2145	5005	2745.498	2259.502
1998	1168.6	7172	2151.6	5020.4	2748.492	2271.908
1999	1621.4	7845	2353.5	5491.5	2751.486	2740.014
2000	1702.4	8107	2432.1	5674.9	2785.76	2889.14
2001	1872.7	8966	2689.8	6276.2	2816.04	3460.16

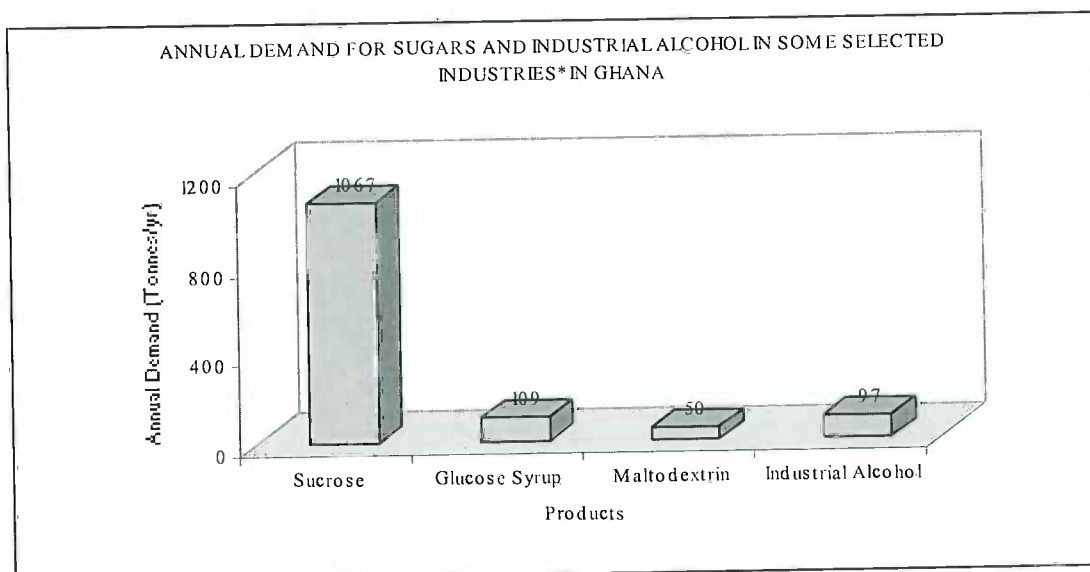
<sup>3</sup> MOFA allowances for Non-Food Use (Seed, Feed and Waste) for Cassava is 30% and per capita consumption of cassava used for the analysis are 149.7 Kg /head / year and 151.4 Kg / head / year for 1995 and 2000 respectively (SRID/MOFA 2001).

**Table 3. Sugar Syrup Imports**

Year	Quantity (Mt)	Value (1000\$)
1996	49	70
1997	83	111
1998	56	56
1999	116	115

Source: FAO website (fao.org)





\* No. of Industries covered for each product: Sucrose:13; Glucose syrup:4; Maltodextrins:1; Alcohol:8

**Table 4. Technical Specifications for glucose syrups and Industrial Alcohols As indicated By User Industries In Ghana**

Glucose Syrups		Industrial Alcohols	
Parameter	Speification	Parameter	Speification
Moisture (%)	15-20%	% Alcohol	96-99
PH	5.5-6.5	Colour	Colourless
DE	45	Odour	Odourless
Colour	Colourless	Contaminants:	
Odour	Odourless	Methanol	0.02%
Taste	Very sweet	Aldehydes/Ketones	0.001%
Clarity	Very clear	Non-Volatile	5mg/100ml
Bacterial count (max)	100 cfu/g	Residues	2ppm.
Fungal Count (max)	100 cfu/g	Benzene	
Pathogens	nil		

**Table 5. Indicators Of Financial/Economic Viability Of Cassava Flour Based Glucose Syrup\* Production In Ghana.**

Indices	Small Scale Glucose syrup production	Commercial Scale Glucose Syrup Producton
Targeted Production Capacity (Mt/yr)	19.5	78
Fresh cassava requirement (Mt/yr)	95	400
NPV (at 30% Discount Rate) (¢)	3,023,264.00	85,755,097.00
IRR (%)	44	137
Break Even Price (¢/kg)	3535	5256
Estimated Selling Price (¢/kg)	4243	5781
Estimated Profits : (¢/kg)	707	515
:(¢/month)	1,148,875.00	3,347,500.00
:(¢/year)	13,786,500.00	40,170,00.00

\*1999 World Market price of Glucose Syrup: \$1/kg = ¢7,600.00/kg

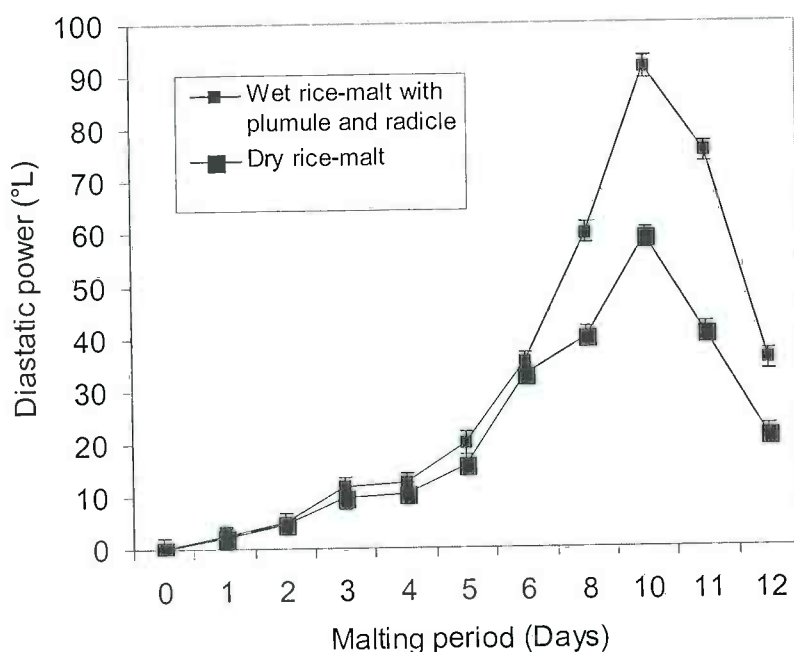


### Summary of activities carried out by UoG

The University of Ghana concentrated on aspects of strategic research into cassava flour and conversion of cassava flour into sugar syrups. Research was conducted through projects carried out by students registered for Master of Philosophy Degrees at the University of Ghana. During the life of the project three MPhil students successfully completed their research activities under the umbrella of project R7418.

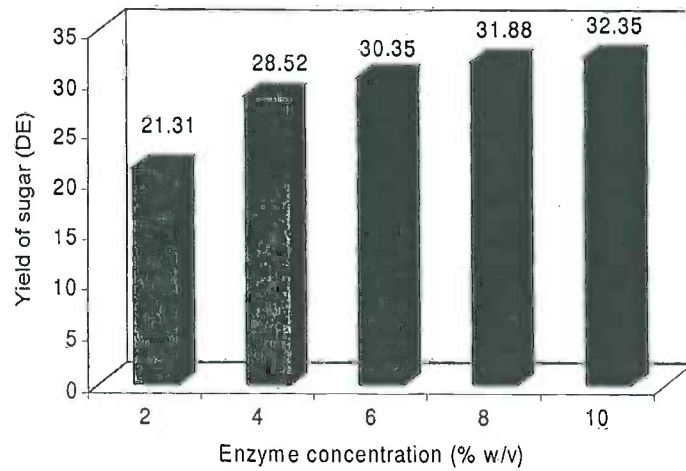
Research centred on the mode of producing cassava flour, production of enzymes from rice seedlings, and optimising the activity of the enzymes through the establishment of basic biochemical conditions to achieve optimum hydrolytic activity for production of sugars from cassava flour. Details of these activities are contained in the summaries below:

On the production of enzymes from rice seedlings, studies were conducted on malted rice in an attempt to produce enzymes from rice malt with high diastatic power for the production of sugar syrup from cassava flour. The germination power of the rice was studied and diastatic power in malted rice determined. Wet rice-malt with plumule and radicle had the required diastatic power.



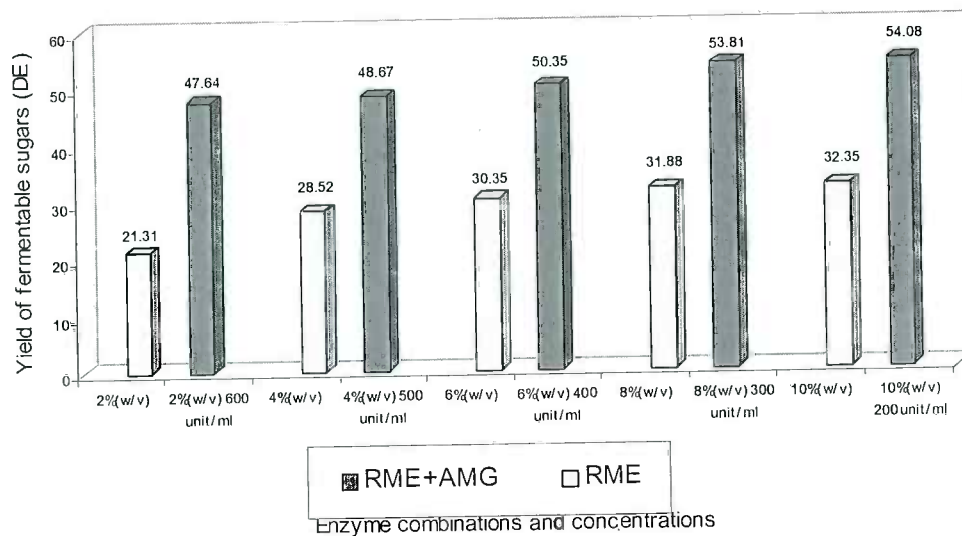
The trend of diastatic power in various malt preparations

On optimising the conditions for production of sugar syrup from cassava flour, wet rice malt was prepared by malting paddy rice at  $28 \pm 2^\circ\text{C}$  for 10 days and the diastatic power determined. Effects of pH and temperature on activities of enzymes in rice malt were studied. Effects of enzyme and substrate concentrations on yield of sugars were investigated and the simultaneous consideration of temperature, pH and time of hydrolysis on yield of sugars were studied using central composite rotatable design and response surface methodology. The optimum operational acidity and temperature of enzymes were pH 5.5 and  $55^\circ\text{C}$  respectively.



Effect of enzyme concentration on yield of sugars

In a study combining rice malt and other industrial enzymes, hydrolysis of cassava flour by the combination of rice-malt extract (RME) and amyloglucosidase (AMG) on yield and type of sugars were investigated. Effect of rice-malt enzyme concentration on rate of liquefaction and AMG concentration on rate of saccharification were studied. The combined effect of RME and AMG on yield of sugars was investigated. Simultaneous consideration of temperature, pH and time was studied using response surface methodology. Types of sugars present in syrups were identified and quantified by HPLC.



Yield of sugars using RME alone and in combination with AMG

### Summary of activities carried out by MoFA

The overall aim of the project was to improve the livelihoods and family income of cassava farmers and processors in rural areas. The activities of the Ministry of Food and Agriculture (Brong-Ahafo) were focussed on adaptive research and technology transfer. MoFA therefore was involved with cassava farmers, primary and secondary processors and end users at village level. Outputs were centred on target groups that were based in Atebubu district and parts of Sene district. The project was involved in two main villages (Watro and Kokofu) and five towns (Atebubu, Kwame-Danso, Prang, Amantan and Yeji).

The key activities were:

- ❖ Baseline study of the status of raw materials and importance of cassava for income generation
- ❖ PRA with bakers on the use of cassava flour in bakery and confectionery industry in Atebubu and Sene districts.
- ❖ Support for farmers to produce cassava chip for research activities.
- ❖ Production of sugar syrups from cassava flour at village
- ❖ Village level methods for production of seedlings from rice/maize
- ❖ Information/awareness seminars on new market opportunities of cassava
- ❖ Preparation of training manuals for rural bakers
- ❖ Linkages between producers of high grade cassava flour in the region and bakers in other surrounding villages
- ❖ Training of bakers in five towns in the use of cassava flour in bakery products
- ❖ Video on cassava flour production and utilisation

A PRA study was conducted at Watro by a multidisciplinary team from MoFA and FRI. From the study, the annual production of cassava in Watro was estimated at 75,000 tons, which are about 30% of the district output. The study provided

information on the availability of cassava in the community which could be a source of raw materials as they showed a lot of interest in the project activities with the idea of generating more income since they are dependent on the production of cassava chips (Kokonte) for their main income. There had been a successful trial of sugar syrup production in Kokofu. Interest was showed among the villages and therefore formed groups to be trained in the sugar syrup production.

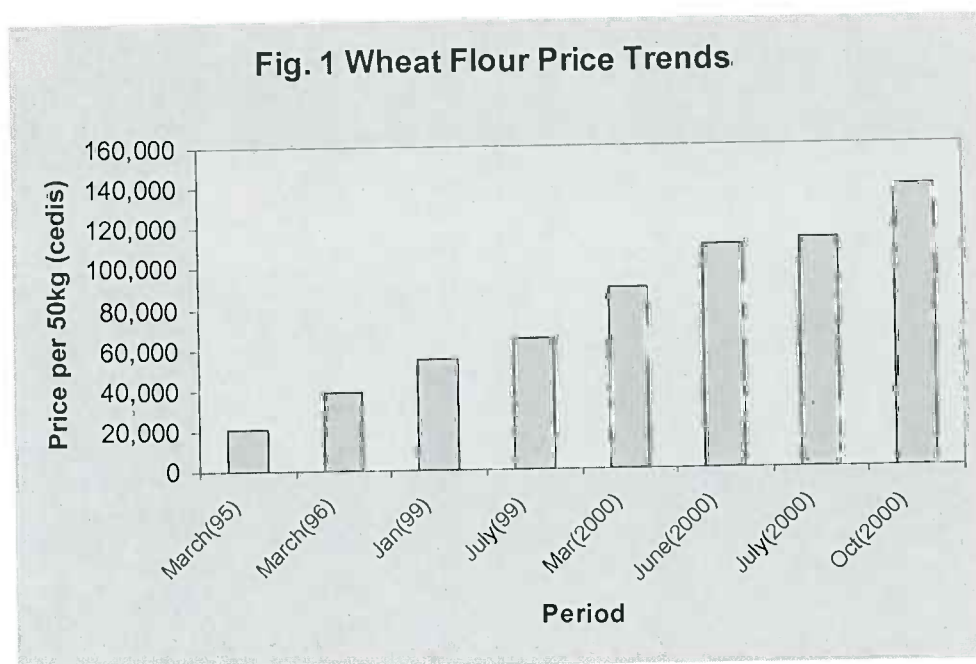
According to bakers in Atebubu, interests in cassava flour has spread wider than Atebubu town, and they requested that support be given for the development of cassava flour production and utilisation by bakers in Atebubu and Sene districts.

To assess level of interest and likely demand for HQCF, a Participatory Rapid Appraisal was conducted with bakers on the use of cassava flour in the bakery and confectionery industry in five towns in Atebubu and Sene districts. This involved the use of a professional baker (Mrs Wilson) from Atebubu to assist in the PRA at five towns (Atebubu, Prang, Amantin, Yeji and Kwami Danso).

The number of active bakers and those in the confectionery business are Atebubu, 30, Prang, 8, Amantin, 7, Yeji, 100 (this includes bakers from surrounding villages) and Kwami Danso 30.

From the PRA, it was realised that the constant rise in the price of wheat flour had become a critical factor to sustainable livelihoods through a gradual reduction in profit margins.

Example of price increase of Sankofa wheat flour price



Increases in the price of wheat flour proved to be the deciding factor in persuading bakers to request support to take on HQCF.

There had been an awareness seminar among producers of cassava at Watro and Kokofu on the other uses of cassava. The feedback from the awareness seminar brought about the interest in the production of cassava based products in Kokofu and Watro

Farmers at Watro had been supported with equipment and other facilities and have been trained in the production of high quality cassava flour (HQCF). About five tons of cassava flour was produced.

Over forty farmers (majority women) at Kokofu had been provided with training in sugar syrup production. The willingness of the farmers to take up the sugar syrup production has brought about the construction of facility at Kokofu not only to be used by Kokofu farmers but also to serve as a facility for future training activities.

As part of the training and support programme a training Manual, 'Baking with cassava flour' was prepared in collaboration with a rural baker so as to provide recipes designed for village conditions.

Over ninety bakers and those in the confectionery industry were trained in the five towns (Atebubu, Prang, Amantin, Yeji and Kwami Danso). A professional baker who is also member of the bakers association was used as a consultant and resource person for the training.

To accompany training manual, MoFA is making a video on the Production and Utilisation of cassava flour. The video is based on the activities of cassava processors and training conducted by MoFA in the use of cassava flour in bakery products.

Bakers from the towns trained have started incorporating cassava flour into bread. Thirty- percent substitution of cassava is used for bread thereby increasing the profit margin by 107%. Profit margins for other recipes are, boofrot, 13%. Togbee, 19%, doughnut 4% and chinchin, 19%.

Watro processors produce cassava flour for local bakeries and contracts from Accra and Takoradi.

In discussions with the farmers/processors the following limitations to uptake of cassava as a business opportunity were identified:

- ❖ Lack of experience and business management skills.
- ❖ Problem of cassava pricing and prompt payment by users
- ❖ Non transparency in the processing group
- ❖ Lack of microfinance to support their activities
- ❖ Limited drying area (patios) and how to finance the increase

Demand for sugar syrup in bakery products and local distilleries was identified in Atebubu town. Watro and Kokofu activities have been successful in production of sugar syrup and helped to raise awareness/interest in wider use of cassava and the demand for cassava based products has developed into more distant areas.

## **Output 2: Cassava flour-based waterproof adhesives for plywood and paperboard manufacture developed.**

### **Summary of achievements**

Cassava flour proved effective (no loss of glue strength) at 45% substitution level as a replacement for wheat flour in plywood glue formulation. Adoption of cassava flour could save the Ghanaian plywood industry £0.5 million per annum given that cassava flour could be produced at less than the price of wheat flour (wheat flour price is kept artificially low by the US PL480 wheat subsidy). However, financial analyses indicate that it is unlikely that cassava flour can be produced at a low enough price to compete directly with wheat flour, hence simple substitution of wheat flour with cassava flour is not commercially viable in Ghana. A more attractive option would be

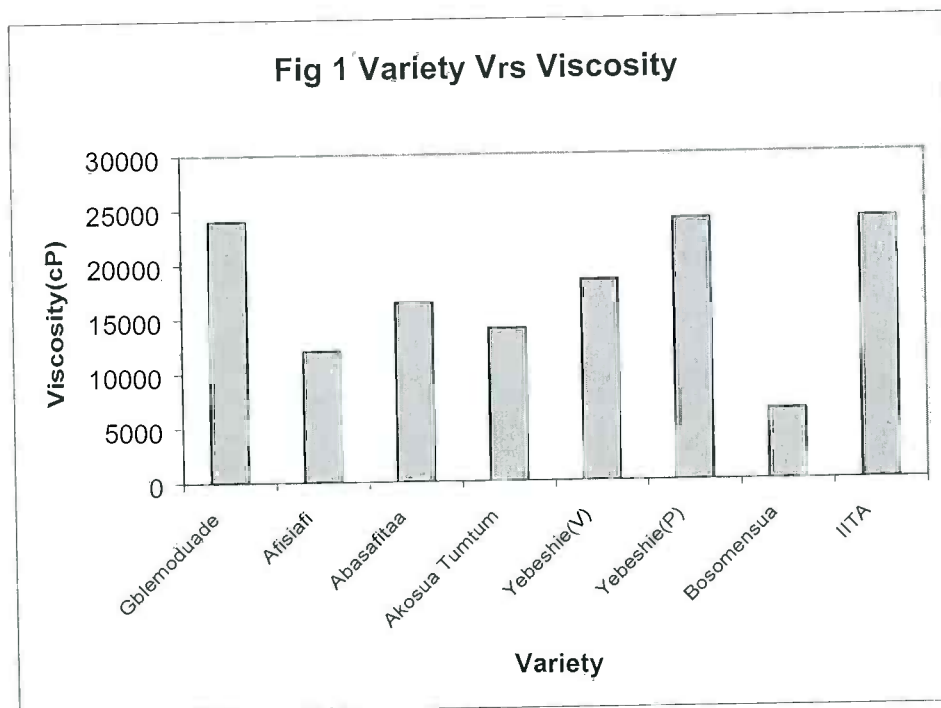


to incorporate cassava flour with cheap locally available natural resins so as to reduce the amount of expensive imported resin used for plywood manufacture. Tannins extracted from waste bark of *Acacia spp*, mixed with cassava flour could be used to replace 40% and 50% of phenol and urea formaldehyde resins respectively. Adoption of this mixture could save the Ghanaian plywood industry £0.9 million per annum and also reduce environmental pollution caused by the release of formaldehyde vapour during plywood production.

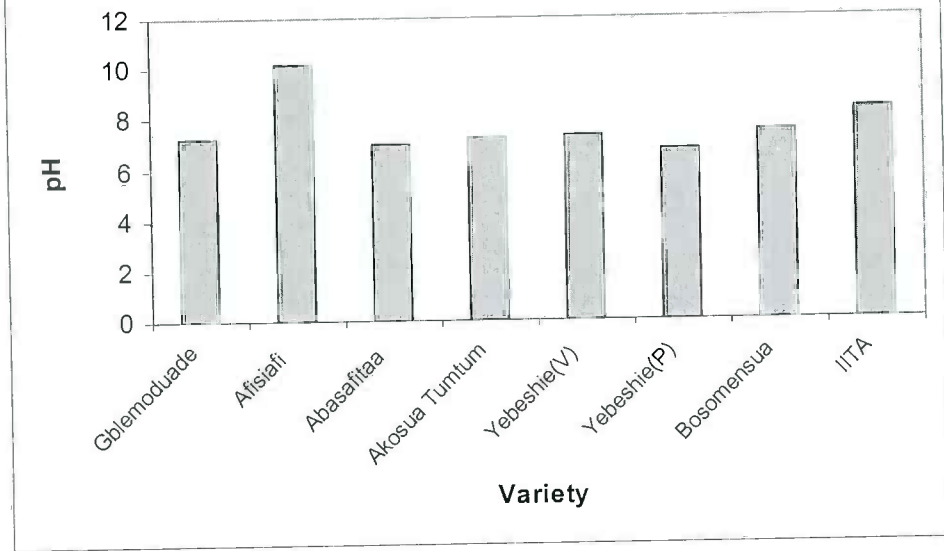
**Summary of activities carried out by FORIG**

**Effect of variety and processing technique on suitability of cassava flour for use in plywood and paperboard adhesives.**

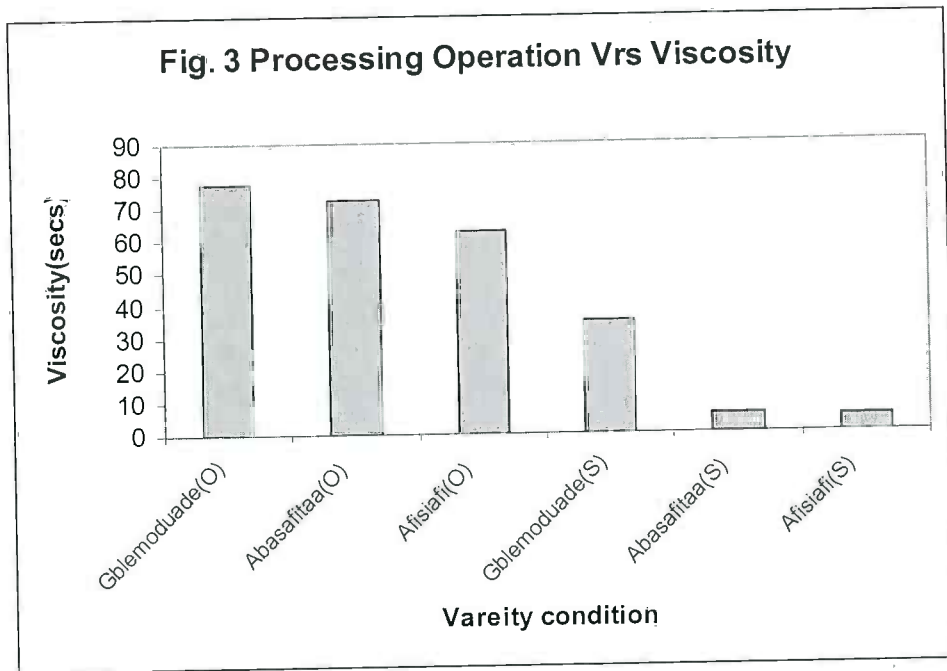
Figures 1 and 2 show the results of studies of the physico-chemical properties of cassava flour prepared from different varieties of cassava. It shows a wide variation in the pH and viscosity values. These differences could be attributed to the variety and the growing area. Based on the formulation studies, the ideal viscosity for cassava flour for adhesive production should be around 15000 +\_ 1000cps. This means that Abasafitaa and Akosua Tumtum both from Brong Ahafo Region are the best varieties for adhesive production of those tested (varieties selected were those commonly grown by farmers in the target production areas, all roots used were obtained from farms in Atebubu District with the exception of Bosomensua which was obtained from Volta Region). The Bosomensua variety from Volta Region is a poor variety for adhesive work while the remainder could be used if blended with Abasafitaa and Akosua Tumtum. Figures 3 and 4 show the effect of processing on these varieties. Sun drying, resulted in an increase in pH with a large decrease in viscosity. Although oven-dried material gave better overall results, the cost of processing was much higher when compared to sun drying. From a practical perspective it was clear that prospective industrial processors will need to take care to ensure uniform selection of variety and processing technique in order to produce a stable product for the plywood and paperboard mills.



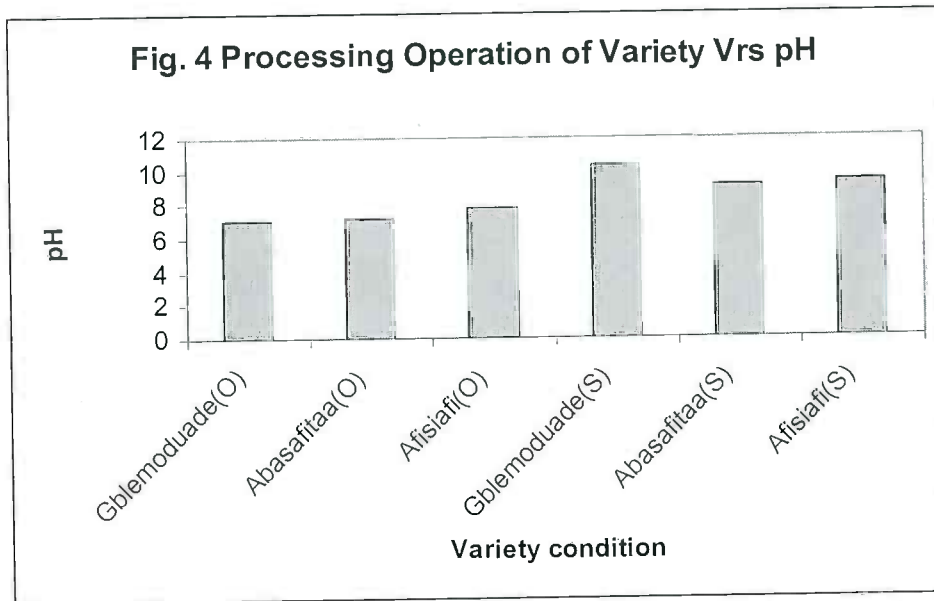
**Fig 2 Variety Vrs pH**



**Fig. 3 Processing Operation Vrs Viscosity**



'O' Oven-dried  
'S' Sun-dried



'O' Oven-dried  
'S' Sun-dried

#### Industrial trials and potential of cassava for use in plywood manufacture

A survey of plywood mills in Ghana revealed that on the average Ghana imported about 3,300,000kg of adhesives worth about 8 billion cedis (CIF) in 1999. The percentage of wheat flour in the adhesive mixture was between 45-66 by weight, the lowest being at NDVP (Ashanti Region) and the highest at Prime Wood (Western Region). In all the industrial runs, wheat flour was replaced by cassava flour without loss in glue strength. At 1999 exchange rates, and at 100% substitution using cassava flour an estimated £500,000 imports could be replaced by cassava flour. If 40% of the adhesive cost is replaced with tannins from local material, £400,000 more could be saved. The overall reduction in imports if cassava and local tannins are adopted will be around £900,000 per annum.

In order to produce a waterproof adhesive, work was undertaken to substitute phenol in P/F resins with locally derived tannin. This has resulted in a complete formulation using phenol, tannin and cassava flour, whereby 40% of the phenol was replaced with tannins. The Phenol/Tannin/Formaldehyde adhesive had the following formulation (all parts by weight).

P/F condensation syrup 200 phenol 140 formaldehyde: 10 NaOH,

Tannin solution: Tannin 100: NaOH 10 and water 280,

Para formaldehyde: 15 and Dry Cassava Flour 10,

This became necessary, because the U/F resin being used by the industry is not waterproof, but P/F is and the cost ratio of urea to phenol is about 1:3. This would mean that with this new formulation, the cost of producing a waterproof adhesive would have been reduced by 40%. This would not only help to alleviate the foreign exchange situation in the mills but would also have positive effect on the environment as toxic fumes from phenol resins can be reduced.

The other activity undertaken was the replacement of 50% of urea in U/F resin with tannins extracted from *Acacia spp.* bark. The concept was to reduce cost and also to improve the waterproofing qualities of the U/F, which is poor compared with P/F. Tannins were extracted from *Acacia spp.* bark. This tree was chosen because it grows well in the Savannah Zones, and since it is a member of the family *leguminaceae* has given positive results with Agro-forestry systems.

### **Output 3: Potential for cassava as an industrial commodity for use in production of sugar syrups, industrial alcohol, plywood and paperboard adhesives promoted to producers, processors and potential users of cassava-based products.**

#### **Summary of achievements**

A combination of industrial trials, training sessions, brochures and manuals, promotional seminars, trade fairs and agricultural shows and media coverage on television and radio and in newspapers has resulted in a steady increase in interest in cassava for non-traditional purposes in Ghana. Awareness seminars conducted by NBSSI attracted 189 participants, and over 100 follow-up enquiries have been received by NBSSI, FRI, MoFA and FORIG. The dissemination strategy of project R7418 has been augmented by integration into the IFAD funded Root and Tuber Improvement Programme, the national business advisory programme of NBSSI, and through circulation of project outputs to IITA in Ibadan and Kampala.

#### **Summary of activities carried out by NBSSI**

NBSSI's primary role is to provide practical support to small and medium enterprises through provision of training and promotional materials, organising seminars and providing access to credit schemes. The key activities for NBSSI were:

- (a) Identification of commercial stakeholders in Sekondi-Takoradi, Kumasi and Accra-Tema.
- (b) Holding of One-Day Awareness/Information Seminars in these urban centres to inform industrialists, commercial bakers, scientists, potential entrepreneurs and policy makers about the industrial potential of cassava.
- (c) Writing of business plans for the production of cassava chips and flour at both the village and urban levels, and comparative analysis of costs and benefits in the use of cassava flour in different bakery products.

The highlights of the reports or outputs of the awareness seminars and business plans showed the following:

- All the stakeholders are aware of the positive potential for the industrial uses of cassava
- Stakeholders are willing and ready to participate in the promotion of industrial uses of cassava.
- It is profitable to produce high quality cassava chips and flour in both Village and Urban levels in areas with relatively cheaper prices for raw cassava.

**Table 1:** Attendance at the Awareness/Information Seminars

STAKEHOLDERS	NO. ATTENDED IN TAKORADI	NO. ATTENDED IN KUMASI	NO. ATTENDED IN ACCRA	TOTAL
1. Plywood manufacturers	2	1	-	3
2. Paperboard manufacturers	3	-	-	3
3. Glue manufacturers	-	2	-	2
4. Caterers/Bakers	10	14	1	25
5. Public Officials (Institutions)	19	20	20	59
6. Research/Educational Officials	4	12	15	31
7. Private Entrepreneurs/Companies	4	7	5	16
8. Food Processors	7	4	5	16
9. Farmers	-	2	2	4
10. Non-Governmental Organisations	4	2	2	8
11. Media Personnel	9	7	2	18
<b>TOTAL</b>	<b>62</b>	<b>71</b>	<b>56</b>	<b>189</b>

On average 60 stakeholders attended each awareness seminar. The large number of media personnel who attended led to wider publicity of the deliberations at the seminars. The responses from the seminars have been very encouraging. Over 100 enquiries have been received from members of the public asking about how to get High Quality Cassava Flour, and how to set up cassava flour processing enterprises. These enquiries were handled by the NBSSI Regional Offices in Sekondi-Takoradi, Kumasi and Accra. District training programmes in the use of cassava flour in bakery products have been held by NBSSI district officers in Esiam in Western Region, and Atebusu in Brong Ahafo region. In all about 40 people were involved in these training sessions.

- (b) **Business Plans:** The four (4) business plans prepared were demonstrated to cassava flour producers in Watro and bakers in Atebusu.

The reports of the awareness/information seminars held in Takoradi, Kumasi, Accra showed that the stakeholders. (i.e. researchers, industrialists, food processors, potential entrepreneurs, policy makers and the general public) appreciated and accepted the industrial potentials of cassava and the financial benefits to the rural farmers. The research outputs were demonstrated to the participants of the seminar and through the mass media (radio, television and newspapers) throughout the country. Plywood and paperboard manufacturers and bakers have accepted to use high quality cassava flour in their products. The business plans prepared for cassava flour production at the village level showed good and profitable potentials for farmers who will engage in these activities as sources for additional incomes. High quality cassava flour production at Watro and Kokofu in the Brong Ahafo region has demonstrated the potential of this business activity as a potential for improving the incomes of farmers at the village or farmer level.



## Section F Evaluating Project effectiveness

### The Purpose

The outcomes of project R7418, include delivery of validated cost effective technologies for production of high quality cassava flour for use in selected bakery products and plywood glue, sugar syrups for food use, industrial alcohol for the chemical industry and a complete paperboard adhesive for the cardboard packaging industry.

In Ghana, the cassava flour processors groups in Watro and Kokofu villages have increased in size from 22 to 60 members (85% women). One group has become self-sustaining with orders coming in from bakers in a nearby town, and a large food processor in Accra. A recent order was worth \$2000, allowing many of the processors to open bank accounts and to spend sums ranging from \$100 to \$150 on their families using income derived from cassava flour. Given that village income levels are <\$500 per annum in many cases, cassava flour represents a significant boost to household income. A private sector investor has established an intermediate processing plant for cassava-based products near to Accra and the project has identified some 20 industries in the food, paperboard, plywood and chemical sectors around Accra, Tema, Kumasi, Sekondi-Takoradi, Sunyani and Berekum. Most of these industries have been involved in industrial trials and have formed links with the intermediate processor. One paperboard manufacturer has started to manufacture cassava-based adhesive using technology developed under project R7418.

At the end of project R7418, the level of impact of the outputs on the purpose was necessarily limited due to the project having to focus most of its effort on strategic and adaptive research issues. However, there was a clearly identifiable shift in emphasis between projects R6504 and R7418, with further changes envisaged for project R8268.

Emphasis of work %	R6504	R7418	R8268
Strategic research	90%	30%	0
Adaptive research	10%	40%	10%
Awareness/ dissemination	0	25%	35%
Uptake by beneficiaries	0	5%	55%

This shift has been made possible by the success of R7418 in raising awareness of the potential of cassava as an industrial commodity. Farmers, intermediate processors and end users have made the commitment to creating a functional market chain for non-traditional cassava-based products. The success of R6504 and R7418 at purpose level will only become apparent during the life of R8268, and longer term impacts may not be seen within the life of the CPHP.

### The Outputs

The degree of achievement for each output has been summarised in the table below. Recommendation and plans for further work to complete studies initiated under R7418 are given in annex 4.

	Signature	Date
Natural Resources Institute (NRI)	.....	.....
Project leader	.....	.....

Food Research Institute (FRI)	.....	.....
Project leader	.....	.....
National Board for Small Scale Industries (NBSSI)	.....	.....
Project leader	.....	.....
University of Ghana (UoG)	.....	.....
Project leader	.....	.....
Ministry of Food & Agriculture Brong Ahafo (MoFA)	.....	.....
Project leader	.....	.....
Forestry Research Institute of Ghana (FORIG)	.....	.....
Project leader	.....	.....

**Summary of achievements at output level for the project on expanded markets for cassava in Ghana (R7418).**

Output	Objectively Verifiable Indicator (OVI)	Comment	Rating
<p>1. Potential for cassava-based sugar syrups assessed, and procedures for conversion of cassava to sugars and industrial alcohol's developed.</p>	<p>1. Assessment completed by March 2000, procedures for conversion of cassava to sugar and industrial alcohol developed by Sept 2001.</p>	<p>Work on this output was successful, with strategic research being validated at village level within the life of the project.</p>	<p>1</p>
<p>2. Cassava flour-based waterproof adhesives for plywood and paperboard manufacture developed.</p>	<p>2. Waterproof adhesive for plywood developed by June 2001, and paperboard by September 2001.</p>	<p>Work on this output is mostly complete, and the paperboard adhesive is ready for adoption by the private sector. However, the work at FORIG was delayed by problems with the Instron system and laboratory press (damaged by a power surge). Work was not completely disrupted but the quality of work was degraded as it was not possible for long periods to obtain reliable quantitative data on the effect of cassava flour on bond strength in plywood boards.</p>	<p>2</p>
<p>3. Potential for cassava as an industrial commodity, for use in production of sugar syrups, industrial alcohol, plywood and paperboard adhesives, promoted to producers, processors and potential users of cassava-based products.</p>	<p>3. Brochures produced and seminars organised for key players and policy makers, with all activities complete by February 2002.</p>	<p>This output has been completely successful and created more than sufficient interest in taking up the outcomes of the project. In fact it became apparent that there was a risk of disappointing many interested parties as the pace of research could not keep up with the demand for products from users and ready markets for potential intermediate processors.</p>	<p>1</p>

### Annex I. Project Logical Framework

Logical framework for the project entitled "Development of new market opportunities, to increase the contribution that cassava makes to sustainable rural livelihoods (R7418)", as included in the approved version of the project memorandum dated 12<sup>th</sup> April 1999.

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
<b>Goal</b>			
<p>Poor people benefit from new knowledge applied to food commodity systems in forest agriculture interface areas.</p>	<p>By 2002, increased numbers of poor households, in two target countries, who use improved storage and agro-processing techniques in an environmentally sustainable manner. By 2002, increased numbers of poor households, in two target countries, benefit from improved marketing and credit systems. By 2005, increased contribution to nutrition of poor households from own produced food. By 2005, increase in income from the sale of fresh and processed crops by poor households in two target countries.</p>	<p>National and local adoption rate surveys.  National food security data.</p>	<p>Poor people invest benefits to improve choices and options for livelihood strategies.</p>
<b>Purpose</b>			
<p>Strategies developed and promoted which improve food security of poor households through increased availability and improved quality of root crops and better access to markets.</p>			<p>Resources managers, producers and processors are able to adopt new knowledge.  Enabling environment exists for widespread adoption of new knowledge.  Capabilities of target institutions maintained at least at...</p>
<b>Outputs</b>			
<p>1. Potential for cassava-based sugar syrups assessed, and procedures for conversion of cassava to sugars and industrial alcohol's developed.  2. Cassava flour-based waterproof adhesives for plywood and paperboard manufacture developed.</p>	<p>1. Assessment completed by March 2000, procedures for conversion of cassava to sugar and industrial alcohol developed by Sept 2001.  2. Waterproof adhesive for plywood developed by June 2001, and paperboard by September 2001.</p>	<p>1. Project reports available.  2. Project reports available.</p>	<p>1. and 2. (a). Stakeholders are willing to collaborate to achieve research outputs. (b). That end users continue to be willing to accept locally produced cassava based products. (c). That secondary processors and end users will be willing and able to invest in realisation of new market opportunities. (d). That the current favourable climate for industrial development (in Ghana) is maintained.</p>

3. Potential for cassava as an industrial commodity, for use in production of sugar syrups, industrial alcohol, plywood and paperboard adhesives, promoted to producers, processors and potential users of cassava-based products.	3. Brochures produced and seminars organised for key players and policy makers, with all activities complete by February 2002.	3. Dissemination materials, and reports on awareness seminars and training sessions available. Deadlines to be determined by progress made with outputs 1 and 2.	3. All stakeholders are willing to participate in seminars and training sessions. That outputs one and two are successful and thus provide material for dissemination.
Activities	Inputs	Means of Verification	Important Assumptions
1.1. Economic and technical requirements of the market for sugars, industrial alcohol's, plywood and paperboard adhesives assessed, and cassava producers and processors in target villages in Brong Ahafo assessed.	Total Cost: £309,190 1.1. Economic and technical assessment involving industries in four commercial centres (Accra, Tema, Kumasi and Cape Coast), and producers and processors in target villages in Brong Ahafo completed by September 1999.	Quarterly and annual reports. 1.1. Technical and economic report available by September 1999.	1.1. Representatives of industries, farmers and primary processors of cassava are willing to co-operate with survey personnel.
1.2. Technical and economic potential of cassava-derived sugars for food industries and village products assessed.	1.2. Evaluation of sugars in industries and local market products in two commercial centres and two villages completed by March 2000.	1.2. Technical and economic report available by March 2000.	1.2. Representatives of processing industries in rural and urban areas are willing to provide necessary information.
1.3. Local sources of plant-derived enzymes identified and village-scale production techniques developed.	1.3. Two techniques for village level enzyme production developed and optimised by March 2000.	1.3. Technical report available by March 2000.	1.3. Stakeholders in village are willing to collaborate with trials.
1.4. Procedures for dextrinisation of cassava at village and industrial scale developed.	1.4. Two techniques for dextrinisation of cassava at village and industrial scale developed by September 2001.	1.4. Technical report available by September 2001.	1.4. Stakeholders in village and industrial setting can be identified and are willing to collaborate with trials.
1.5. Process for conversion of cassava-derived sugars to industrial alcohol developed.	1.5. Conversion of cassava derived sugar to industrial alcohol optimised (for Ghanaian conditions) in one factory by September 2001.	1.5. Technical report available by September 2001.	1.5. Producer of industrial alcohol is willing and able to collaborate with trials.
1.6. Socio-economic implications (integrated with 1.2-1.5) of encouraging exploitation of opportunities for sugars and industrial alcohol assessed.	1.6. Economic assessments for activities 1.2-1.5 completed by March 2000(1.2/1.3), and September 2001(1.4/1.5) respectively.	1.6. Economic reports for activities 1.2-1.5 available by March 2000 (1.2/1.3), and September 2001 (1.4/1.5) respectively.	1.6. Stakeholders are willing to collaborate, and no technical difficulties arise that could interfere with economic assessments.
2.1. Cassava flour-based waterproof adhesives for plywood developed.	2.1. Cassava based waterproof plywood adhesive developed in two factories by June 2001.	2.1. Technical report available by June 2001.	2.1. Plywood industries are able to collaborate with trials, and do not face any unforeseen technical or economic difficulties.
2.2. Cassava flour-based waterproof adhesives for paperboard developed.	2.2. Cassava based waterproof paperboard adhesive developed in two factories by September 2001.	2.2. Technical report available by September 2001.	2.2. Paperboard industries are able to collaborate with trials, and do not face any unforeseen technical or economic difficulties.
2.3. Socio-economic aspects of exploitation of opportunities for plywood and paperboard assessed (integrated with 2.1 & 2.2).	2.3. Economic assessments for activities 2.1 and 2.2 completed by June 2001 (2.1) and September 2001 (2.2) respectively.	2.3. Copies of reports on economic assessments available by June 2001 (2.1) and September 2001 (2.2) respectively.	2.3. That representatives of the paperboard and plywood industries will be will to provide information required for economic analysis.
2.4. Independent review of all project activities.	2.4. Independent review of all project activities completed by June 2001.	2.4. Copies of mid term review report available by June 2001.	2.4. Project beneficiaries are willing to participate in the review.



<p>3.1. New market opportunities for cassava promoted on a pilot scale to key players within the market system, and to national and local policy makers.</p>	<p>3.1. Brochures produced and at least three seminars and training sessions held for key players in the various market systems and policy makers by February 2002.</p>	<p>3.1. Copies of dissemination material available, and reports on awareness seminars and training sessions. Dates for dissemination activities and reporting deadlines will be determined by progress made with other activities.</p>	<p>3.1. All stakeholders are willing to participate in seminars and training sessions. That outputs one and two are successful and thus provide material for dissemination.</p>
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## **Annex II.**

### **Results of end of project workshop**

Dissemination and awareness creation was an ongoing process integrated into the project under output 3, with NBSSI handling the majority of urban activities and MoFA focussing on dissemination in the rural areas. Because of the nature of the project it was not considered necessary to hold an end of project workshop. As an alternative awareness creation and dissemination seminars were conducted over a two year period in the key urban centres of Accra / Tema, Kumasi and Sekondi-Takoradi. Rural activities focussed on Atebubu, Yeji, Amantan, Kwame-Danso, Prang, Watro and Kokofu. The outcomes of these activities are reported under output 3.

## **Annex III.**

### **Target Institution's workplan for adopting project outputs**

In March 2002, the R7418 project team met to prepare their annual report and consider ways of maximising adoption of the outputs of projects R6504 and R7418. As a result an outline strategy document was prepared and circulated to all members of the R7418, CPHP Regional Co-Ordinator for West Africa and the CPHP Programme Manager. A copy of this document is given below.

### **OUTLINE STRATEGY / APPROACH OF WORK REQUIRED FOR ADOPTION OF OUTPUTS FROM PROJECTS R7418 AND R6504 IN GHANA & NIGERIA (OCTOBER 2002- MARCH 2005)**

#### **Taking the work forwards in Ghana & Nigeria**

The essence of the expanded markets project (R6504 & R7418) has been to work with the producers and end-users of cassava-based products throughout the project, for the mutual benefit of all partners within the market chain.

In the period from April 1996 to June 2002, the current expanded markets project has achieved its research objectives and a limited amount of uptake of the research outputs by producers and end-users of cassava-based products. Commercial interest in the outputs of the project is considerable but commercial uptake is hindered by the following difficulties:

- Unwillingness of many commercial partners to take the risk of investing in cassava-based products without access to risk limiting financial measures
- Problems of access to capital (especially loan facilities)
- The need for a much larger awareness and training campaign
- The need for adequate post-training support for rural processors and end-users of cassava-based products
- Concerns over quantity, quality and reliability of supply of cassava-based products by end-users
- Problems with formation of linkages between producers and users (especially price setting, and credit facilities)
- Requirement for further completion of research on use of sugar syrups in foods before uptake can take place
- Supplies of cassava exist, end-users are keen to purchase cassava-based products, and farmers are capable of producing small-amounts of high quality cassava flour and sugar syrup (enough to meet the needs of rural bakers in nearby towns), but there is no intermediary to organise production of cassava-based products on a sufficient-scale to meet the demands of the larger industries (plywood, paperboard and larger food industries)

To overcome these difficulties a 3<sup>rd</sup> phase of CPHP funded work was proposed that would run in parallel to a Business Linkage Challenge Fund (BLCF) project. The primary objectives of the CPHP project would be to support uptake of cassava-based products by end-users, and to help establish an intermediate processor to complete the market chain. The BLCF project would provide the necessary financial support for the intermediate processor and end-users of cassava-based products. Micro-

finance for farmers involved in cassava production and small-scale rural processing of flour and syrups would be provided by the CPHP project.

A summary of the areas to be covered under the CPHP project with suggested partners and roles is given in table 1.

There is clearly scope for extending the work to Nigeria, but this will require careful development (see below):

### **Scope of the work**

In **Ghana** the following sectors have already been identified as having the most potential for development in the short to medium term:

- Cassava flour in bakery products (rural & urban markets)
- Cassava-based sugar syrups in bakery and other foods
- Cassava flour-based adhesive for paperboard
- Cassava flour as an extender for plywood glues
- Cassava-based industrial and potable alcohol
- Cassava flour for textile sizing
- Production of high quality versions of selected traditional foods for centralised reprocessing for urban and export markets

There appears to be little potential for development of the livestock feed and starch processing sectors in Ghana at the present time.

In **Nigeria** it will be necessary to examine all sectors, it maybe that livestock feed, or trading in fresh cassava or starch processing offer potential. This being the case ample information exists from previous RNRRS projects and regional Africa work to develop these sectors.

### **Identification of additional partners in Ghana**

The existing project team can provide:

- Technical and economic support for market development
- Training and extension in rural and urban locations
- Support for small-scale industries to access market opportunities.

Additional partners are required to:

- Review existing policy outcomes on cassava in Ghana, and develop positive policy frameworks for expanding markets for cassava (Government Ministry dealing with relevant area of policy development)
- Administer micro-finance schemes for farmers and small-scale entrepreneurs who would not be eligible to benefit from BLCF (Appropriate NGO)
- Close, day to day support for rural producers and processors of cassava-based products (Appropriate NGO)

It will be necessary to identify and develop relationships with potential partners prior to the project development meeting in July 2002. This could be achieved (using an FRI economist) by developing a shortlist of potential NGO partners, visiting potential partners for semi-structured discussions, analysis of discussions so as to select partners to be invited to the project development meeting.

This should be considered as part of the project development process and will require funding to ensure success.

## **Nigeria**

Why should we extend the expanded markets work to Nigeria?

- Largest producer of cassava in Africa - supply base exists
- Well developed industrial base - should offer scope for uptake of Ghana work
- Large population - offers larger market size for cassava-based products
- IITA work on bakery products indicates +ve market acceptability for cassava in foods

To take the Nigerian side of project forwards need:

- A survey of market opportunities for cassava in Nigeria (using model developed at NRI) to assess size of different sectors, source/cost of existing raw materials, scope for replacement with cassava-based products, and to assess the supply base for cassava, policy environment for development of cassava.
- To identify and make approaches to potential partners (research organisations, training & extension, NGO's, business support, private sector {producers & users}) so as to develop a list of recommended partners organisations to be invited to a project development meeting in Accra.

### **Market Opportunities Survey**

For this survey we need the following:

- An initial point of contact (Dr Sanni University of Agriculture, Abeokuta)
- A partner organisation in Nigeria with access to vehicles, fuel, power, computers and personnel in the form of food technologists and market economists (IITA, Ibadan)
- A set of teams of technologists & economists to carry out the work (suggest 2 staff from NRI, 2 from FRI & 4 from Nigerian partner organisations)
- Finance to support 3 weeks work in Nigeria (includes report preparation)

The Nigerian survey is an essential prelude to development of the final phase of the expanded markets project, and should be funded as part of project development, rather than from within the project itself.

### **TIMETABLE (SUGGESTED):**

- Regional strategy released by Regional Co-Ordinator (April 2002)
- Identification of partners in Ghana (April-May 2002)
- Outline of project prepared "Concept note" for evaluation/discussion (May 2002)
- Discussion of BLCF proposals with prospective private sector partners (May 2002)
- Nigerian survey (June 2002)
- CPHP Project development meeting Accra (July 2002)\*
- Project memorandum ready for evaluation (late August 2002)\*
- Project memorandum finalised (September 2002)\*
- Project inception meeting (October 2002)\*
- Mid-term review of progress (February 2004)\*
- Project completion (March 2005)\*

\* = It is proposed that development and implementation of a BLCF project should occur in parallel to the CPHP project in Ghana. The two projects would be closely integrated and work towards common objectives.



### **Project Co-ordination**

The following structure is suggested (based on successful approaches developed in phase 1 and 2 of the expanded markets project):

- Overall Project Co-Ordinator (overall management including finance)
- Country Co-Ordinators for Ghana & Nigeria
- Dissemination Co-Ordinators for each country
- Individual Project Leaders for each partner organisation

Ongoing activities to be developed and integrated via electronic discussion groups and yearly planning meetings.

A. J. Graffham (NRI)  
N. T. Dziedzoave (FRI)  
L. K. Krampa (MoFA)  
E. O. Boateng (NBSSI)  
Date: 15<sup>th</sup> March 2002

**Table 1.** Summary of work areas and partner involvement<sup>1</sup> for the proposed 3<sup>rd</sup> phase of the CPHP funded project on expanded markets for cassava.

Work Area	Activity	Potential Partners
1.0 Production of cassava-based products	1.1 Production of cassava for industrial use	Farmers & farmers groups in Brong Ahafo & upper part of Volta Region
	1.2 Small-scale production of cassava flour in rural areas	Individual & processing groups in village/small town locations
	1.3 Medium/large-scale production of cassava flour (food & plywood use) at a centralised processing plant	T&CG, Sunny Foods, ELSA Foods or similar business
	1.4 Production of paperboard adhesives	Wordsworthy Press, Polykraft, Kumasi Glue or similar operation
	1.5 Small-scale production of sugar syrups in rural areas	Individual & processing groups in village/small town locations
	1.6 Medium/large-scale production of sugar syrup at a centralised processing plant	ELSA Foods, T&CG, Sunny Foods or similar business
	1.7 Small-scale production of industrial/potable alcohol in rural areas	Co-operative Distillers Association at District & Regional level.
	1.8 Medium-scale production of industrial alcohol at a centralised processing plant	Primary distillation by one of the large distillers in Accra or Tema, or redistillation of material supplied by smaller rural distillers
2.0 Utilisation of cassava-based products	2.1 Cassava flour & sugar syrup in bakery products in rural areas	Rural bakeries and Distilleries
	2.2 Cassava flour & sugar syrup in bakery products in urban areas	Small-bakeries and larger food industries such as Fairbons Biscuits
	2.3 Cassava flour as an extender for plywood glue	Plywood mills in Kumasi, Takoradi, Sunyani and Berekum who have already expressed interest in using cassava flour
	2.4 Cassava flour-based adhesives for paperboard	Polykraft, Wordsworthy, Pakrite & others at Tema, Accra & Takoradi
	2.5 Utilisation of industrial alcohol	Pharmaceutical & industrial users to be identified

Table 1. Continued.

Work Area	Activity	Potential Partners
3.0 Market development & Business support	3.1 Raising awareness of potential of cassava & promoting cassava-based products	NBSSI & MoFA with support from FRI, NRI, FORIG & UoG (Legon) & NGO
	3.2 Training of extension agents, NGO representatives & producers and users of cassava-based products	MoFA, FRI, NRI and commercial experts (ie bakers) for initial training activities, later activities can also use NGO personnel
	3.3 Production of training & dissemination materials	NBSSI & MoFA with support/inputs by NRI, FRI, UoG (Legon) & commercial partners
	3.4 Preparation of business plans & cost-benefit analyses for commercial partners	NBSSI with inputs by FRI, NRI, MoFA, FORIG and commercial partners
	3.5 Provision & administration of micro-financing for small-scale entrepreneurs in rural and urban areas	Provision by rural/development bank Rural administration by identified NGO Urban administration by NGO
	3.6 Provision of technical support for producers & users of cassava-based products	FRI, FORIG, MoFA (BA) NRI, UoG (Legon)
	3.7 Provision of business management support for small-scale businesses	In rural and urban areas, combination of NBSSI and appropriate NGO
	3.8 Provision of market mediation	In rural areas = NGO (to be identified) with support from FRI and NRI In Urban areas = NBSSI with support from FRI and NRI
	3.9 Completion of near market research on incorporation of sugar syrups in food products & conversion of sugar syrups to industrial alcohol	FRI, NRI & UoG (Legon)
	3.10 Assessment of existing policy outcomes, and development of a positive policy framework for promotion of non-traditional uses for cassava	Partner to be identified but suggest Ministry closely connected with development of Agri-business

1 = Details of partners are given for Ghana (where known), partners for Nigeria will have to be identified before the project development meeting.

A. Graffham, N. Dziedzoave, L. Krampa & E. Boateng (15/3/02)

Following on from this document a meeting was organised for Ghanaian stakeholders in Accra in May 2002. At this meeting, a proposal team was established to prepare a proposal in the form of a pre-concept note (PCN) for CPHP funding. In view of the time constraints and limitations on funding it was decided to not to take forward the Nigerian side of the work at this stage, but to seek to take matters forward through the bilateral programme in 2003, if the CPHP proposal proved successful.

The PCN proposal (copy below) was successful and led to the development of a full concept note (approved September 2002) and project memorandum (approved December 2002). The new CPHP project R8268 is scheduled to run from January 2003 until December 2004. Two commercial organisations (Amaasa Agro-Processing Company and Feed and Flour Ghana Limited) have stated to develop a proposal for the BLCF. FRI and NRI supported the early stages of this proposal but the BLCF coalition is likely to broaden as the proposal develops.

### **PRE-CONCEPT NOTE**

**Project Title: Sustainable uptake of cassava as an industrial commodity**

**Project Partners & their Full Contact Details:**

The Food Research Institute of Ghana (FRI) and the Natural Resources Institute of the United Kingdom (NRI) are co-ordinating the development of this proposal. The proposal co-ordinators (nominated at the thematic workshop on cassava held in Accra on 29<sup>th</sup> May 2002) are Mr Nanam Dziedzoave of FRI ([nanamtay@hotmail.com](mailto:nanamtay@hotmail.com)), Dr Pan Nii Johnson of FRI ([panijohnson@idngh.com](mailto:panijohnson@idngh.com)) and Dr Andrew Graffham of NRI ([a.j.graffham@gre.ac.uk](mailto:a.j.graffham@gre.ac.uk)), Dr Stephanie Gallat of NRI ([sgallat@ghana.com](mailto:sgallat@ghana.com)).

#### **Ghana**

(a). Potential Private Sector partners.

The following is a list of potential private sector partners some of whom have expressed interest in developing work under the current R7418 and R7580 projects, and others who attended the recent thematic workshop on cassava in Accra. The inclusion of names at this stage does not imply a commitment to involvement in the project. However, it is intended that at least one of these partners would develop credible business proposals during the development of the project memorandum and go forwards to setting up processing operations to bridge the gap between the farmer and the potential end users of cassava-based products.

- (i). Amasa processing Company Contact: e-mail (to be notified)
- (ii). ELSA Foods Contact: Mrs E. Maldini-Afriye e-mail: [elsafoods@infonetghana.com](mailto:elsafoods@infonetghana.com)
- (iii). Feed and Flour Limited Contact: Dr D. Pessey e-mail: [depessey@yahoo.com](mailto:depessey@yahoo.com)
- (iv). Hankson Limited Contact: Wing Cdr (rtd) G. Atadja e-mail: [gack-hanckson@yahoo.com](mailto:gack-hanckson@yahoo.com)
- (v). Polykraft Contact: Mr N. Devanand (to be notified)
- (vi). Suni & Suni Contact: Mr Sunny Kumi e-mail: [sunnysofine@yahoo.com](mailto:sunnysofine@yahoo.com)
- (vii). Wordsworthy Press Contact: Mr P. Kpeglar, e-mail: [wordsworthy-press@another.com](mailto:wordsworthy-press@another.com)

(b). Non-Government Organisations

The major role for an NGO partner in this project will be to provide close support for small-scale farmers in Atebubu District, access to micro-finance and training in business management skills. Two NGO's have expressed interest in the proposal at this stage.

- (i). APED Contact: Ms Isabella Combey e-mail: [aped@wvi.gh](mailto:aped@wvi.gh)
- (ii). ADRA Contact: Mr L. Djarbeng, e-mail: [ldjarbeng@adra.org.gh](mailto:ldjarbeng@adra.org.gh)

(c). Government Institutions

The bulk of project activities required to support development of a sustainable market chain for cassava-based products will be provided by national institutions. As a range of different

professional skills are required for this project, several institutions will be needed to cover the different areas effectively.

(i). Food Research Institute (Product optimisation, technical backstopping, socio-economics, training and quality control systems) – Contact: Mr N. Dziedzoave, e-mail: [nanamtay@hotmail.com](mailto:nanamtay@hotmail.com)

(ii). Forestry Research Institute of Ghana (product development, product optimisation and technical backstopping in the field of paperboard) – Contact: Dr N. Darkwa, e-mail: [ndarkwa@forig.org](mailto:ndarkwa@forig.org)

(iii). Ministry of Food and Agriculture (Brong Ahafo) (Promotion, Awareness creation and extension) – Contact: Mr L. K. Krampa, e-mail: [gtzsun@ncs.com.gh](mailto:gtzsun@ncs.com.gh)

(iv). National Board for Small Scale Industries (Socio-economics, promotion & awareness creation) – Contact: Mr E. O. Boateng, e-mail: [nbssided@gh.com](mailto:nbssided@gh.com)

(v). National Institutional Renewal Programme (Policy development) – Contact: Mr Anthony Adu-Baffour, e-mail: [adubaffour@africaonline.com.gh](mailto:adubaffour@africaonline.com.gh)

(vi). University of Ghana (Product development & technical backstopping) – Contact: Professor G. S. Ayernor, e-mail: [sayernor@yahoo.com](mailto:sayernor@yahoo.com)

### **Nigeria**

The Nigerian partners for this project will be identified as part of a separate study of expanded markets for cassava in Nigeria.

### **United Kingdom**

Natural Resources Institute (NRI), University of Greenwich

Contact: Dr Andrew Graffham e-mail: [a.j.graffham@gre.ac.uk](mailto:a.j.graffham@gre.ac.uk)

NRI has the potential to be involved in provision of specialist knowledge of cassava-based products for product optimisation, and technical backstopping, in socio-economic activities, and in the development of proposals for partial funding of the medium scale processing factory by DFID's BLCF.

**Duration and Location of Project:** 2 years. Ghana and Nigeria

In Ghana production activities will be centred around Atebubu District in Brong Ahafo, supplying local users and industrial users in Accra, Tema, Kumasi and Sekondi-Takoradi.

An expanded markets survey (funded separately to the current proposal) is planned for Nigeria to identify the size and level of demand from potential markets, potential production areas and private and public sector partners to develop project activities in Nigeria.

**Date Of Submission:** 8<sup>th</sup> June 2002

### **Background:**

Cassava is a key food security crop in Ghana, and is of particular importance to low income farmers (including many women), because it can provide reasonable yields on marginal soils with few inputs, even under drought conditions. In 1998 the International Fund for Agricultural Development committed \$10 million towards increased production of cassava in Ghana. However, increasing production can only contribute to improving livelihoods if farmers have markets for their produce. Needs assessment studies funded under the Regional Africa Project (Kleih *et al.* 1994) highlighted farmers' concerns to expand market opportunities for cassava and improve producer prices.

Studies under the CPHP (Day *et al.* 1996) have demonstrated that market opportunities exist in Ghana that would enable cassava to contribute significantly to poor people's livelihoods. The starting point for these markets is the conversion of fresh cassava into a stable, dried form (chips/grits or flour) that can be stored until required for sale or further processing.

Although dry chips command a lower price than fresh roots they have proved attractive to farmers due to their greater shelf life and market stability. Improved small-scale chipping technologies have enabled small groups of farmers in Brong Ahafo to produce high quality chips for sale at a profit. Chips can be used for livestock feed without further processing, or milled into flour for food or industrial purposes. Previous CPHP research by Dziedzoave *et al.* (1998) developed food-grade cassava flour with potential to substitute for at least 50% of the



300,000 tonnes of wheat flour imported to Ghana each year. Cassava flour has been used successfully to substitute for wheat flour as an extender in plywood glues, and as the basis of non-waterproof adhesives for the paperboard industry. Studies indicate that cassava flour has considerable potential as a raw material for production of sugars and industrial alcohol for use in Ghana's expanding industrial sector.

There is also a growing urban market for convenience, high quality cassava based foods (Research International, 2001). As people's lifestyles in urban centres change, they have less time to buy and prepare traditional foods. Increasingly, they are demanding a convenient product with an extended shelf life that can be speedily prepared. There is also an increasing awareness of food safety and quality issues, and the realisation that traditionally processed foods are often prepared under unhygienic conditions. Consumers want traditional foods, but need reassurance that those foods have been hygienically prepared and are safe to eat.

Cost benefit analyses (Boateng, 2002) of the different processing options for cassava, indicate that it will be difficult to produce HQCF at a price to compete directly with heavily subsidised wheat flour, thus rendering plywood extender and some bakery products unattractive. However, selected bakery products gave good profit margins due to the ability to reduce quantities of other expensive ingredients in the presence of cassava flour. Paperboard adhesive proved to be the most attractive option being relatively simple to produce, with a large saving on imported products and reasonably large market. Sugar syrup and industrial alcohol are also attractive areas that merit further development. Many of the market opportunities outlined above could be taken forward as commercial concerns if economies of scale are exploited and cost of production reduced. However, cassava products are currently not processed on a commercial scale. Our research suggests that the critical missing link which has prevented uptake of these technologies on a commercial scale is the absence of an integrated supply chain, which can provide end manufacturers with an assured supply of consistent quality cassava flour (or chips) at a competitive price. Therefore, the development of a commercial, medium scale plant dedicated to processing of intermediary cassava products is essential for the commercialisation of cassava based industries.

The current project aims to take the final step towards development of cassava as an industrial commodity by developing the supply chain and supporting the creation of a medium-scale processing industry to convert cassava into cassava-based products to meet the demand from end users. It is also intended that the successful outcomes of the research in Ghana be transferred to Nigeria. Nigeria has a large supply production and consumer base, and should be able to benefit readily from the research carried out by CPHP in Ghana.

#### **Project Purpose or Objective:**

This project focuses mainly on output 2 (90% of the work) of the current CPHP strategy with a smaller research component (10% of work).

The purpose of the project is: To promote sustainable industrialisation of cassava as a means of improving rural livelihoods.

The overall objectives of the project are:

- Improve livelihoods of cassava farmers and small-scale processors through development of expanded markets for cassava.
- Enhance rural employment opportunities through small and medium-scale processing operations in cassava production areas.
- Establish a functional market chain for cassava-based products.
- Encourage production and utilisation of cassava-based products.
- Creation of a positive policy framework for non-traditional uses of cassava in Ghana and Nigeria.
- Establish strong linkages between private sector and research institutions for sustainable development and uptake of marketable technologies.

**Project Activities:****Output 1:**

- 1.1 Formation of financial linkages and development of detailed financial proposals and business case required to access funds for development of the medium-scale processing factory.
- 1.2 Provision of micro-finance for small-scale processors.
- 1.3 Provision of training in business management skills for small-scale processors.
- 1.4 Provision of training in processing technologies for small and medium-scale processors.
- 1.5 Fabrication, installation and testing of machinery required for production of cassava-based products (chips, grits, HQCF, paperboard adhesive and sugar syrup).
- 1.6 Organisation of industrial experience visits for factory management to established cassava-based industries in other parts of the world.
- 1.7 Provision of technical backstopping for factory during the first two years of production.
- 1.8 Production and distribution of cassava-based products to meet user demands in terms of quality, quantity and timeliness of delivery.
- 1.9 Monitoring and evaluation of rural employment creation and income generation for farmers via monitoring of factory records of raw material purchases, production, sales and distribution of cassava-based products.

**Output 2:**

- 2.1 Development and implementation of quality assurance systems to ensure quality from farm gate through to the end user of the cassava-based product.
- 2.2 Completion of product development activities initiated under projects R7418 and R7580 (that are considered essential for successful development of cassava as an industrial commodity) and optimisation of products under commercial conditions.
- 2.3 Preparation of business plans and cost benefit analyses, and validation of the economics of production and utilisation of cassava-based products.

**Output 3:**

- 3.1 Formation of market linkages from farmer through intermediate processor to the end users.
- 3.2 Provision of micro-finance for farmers to encourage expansion of cassava production to meet demands from industrial users.
- 3.3 Organisation of small-scale farmers into commercially sustainable production units to supply cassava to the processing industry.
- 3.4 Raising awareness of farmers, small-scale processors and end users as to the benefits of locally produced cassava-based products.
- 3.5 Participatory field and factory trials for end users on the use of cassava-based products in their production process.
- 3.6 Provision of technical support for end users of cassava-based products.
- 3.7 Organisation of industrial experience visits for end users to established cassava-based industries in other parts of the world.
- 3.8 Establishment of a system for conflict resolution within the market chain.
- 3.9 To carry out a baseline survey of farmers and small-scale processors to assess current livelihood status and then to carry out ongoing monitoring and evaluation to assess the impact of the project on livelihood status of the beneficiaries.

**Output 4:**

- 4.1 Preparation of a promotional package (video, overheads with notes, colourful leaflets) to demonstrate the benefits of industrialisation of cassava for national policy makers.
- 4.2 To conduct seminars for senior government officials to promote the concept of industrialisation of cassava and the importance of a conducive policy environment.
- 4.3 Establishment of a working group to develop proposals for policy interventions to promote cassava industrialisation.

**Project Outputs:**

The outputs are as follows:

Output 1: Viable small and medium-scale processing facilities for production of cassava-based products established.

Output 2: Processing technologies, quality assurance systems and economics of production and utilisation of cassava-based products validated.

Output 3: Functional supply chain for cassava-based products created, and utilisation of cassava increased.

Output 4: Policy makers sensitised to the benefits of industrialisation of cassava, and the need to develop policies to promote utilisation of cassava-based products.

### **Contribution of Project Outputs:**

Successful delivery of the outputs will:

- Enhance livelihoods of cassava farmers and small-scale processors through expanded markets for their products.
- Create employment opportunities in rural areas.
- Establish a functional cassava processing industry and supply chain to meet the demand for cassava-based products from industrial users.
- Assist in the creation of a positive policy environment for development of cassava as an industrial commodity.

### **How will the outputs be delivered to the intended beneficiaries?**

The dissemination strategy for this project has been divided along the lines of the different groups of beneficiaries:

- (a). Farmers will be supported with training in business management and access to microfinance, and assistance to develop into credible business units to supply cassava to the process industry. In addition support will be provided to ensure that the quality of the cassava roots meets factory needs.
- (b). & (c). Small and Medium-scale processors will require a high level of support, starting with help to put together the business case for the establishment of the factory and following through with training in processing techniques, equipment fabrication, product development and optimisation and ongoing technical backstopping during the life of the project. In addition the project team will develop quality specifications and a workable quality assurance system, and set up a sustainable mechanism for conflict resolution, as conflict within the market chain has been identified as one of the major causes of failure of many business opportunities for cassava in other parts of the world. In the case of small-scale processors the project team will provide training in business management and access to micro-finance to develop business opportunities for cassava.
- (d). End users of cassava-based products will be supported by the project through awareness creation seminars, in house training in the use of cassava-based products in their process, and through ongoing technical backstopping during the life of the project.
- (e). In Ghana it is suggested that NIRP take the lead in developing and delivering a promotional package for senior policy makers in national government, and in organising a working group to develop policy interventions to support industrialisation of cassava.

### **Beneficiaries:**

The Beneficiaries are:

- (a). Cassava farmers – will benefit from access to an expanded and more reliable market for their cassava that will provide a more stable income stream for the household. In addition training in business management skills and access to micro-finance will enable farmers to develop their farms and derive greater financial returns on their investment.
- (b). Small-scale processors – will benefit not only from the additional income derived from processing activities, but also from having access to an alternative source of business activity during the dry season when they have little work to do on their farms.
- (c). Medium-scale processors – will benefit in terms of income from cassava-based products, and opportunities to expand the business beyond the life of the CPHP project as they build up a good reputation with their clients.
- (d). Small-scale end users (such as bakers) – will benefit from reduced production costs and increased profit margins by incorporating cassava flour into bakery products, where cassava has been shown to have a competitive advantage over wheat. Large-scale end users (such as paperboard factories) – will benefit from savings in foreign exchange, reductions in dead stocks and release of working capital.
- (e). The national economies of Ghana and Nigeria – will benefit through savings in foreign exchange via reduced reliance on imported materials.
- (f). The local community in Atebubu District – will benefit in terms of the generation of rural employment. The labour requirement for the factory and small-scale units would peak during

the dry season (farming off-season) thus providing alternative employment at a time when little farm work is available.

**Risks and Assumptions:**

The major risks and assumptions for this project are:

The development of the medium-scale factory as a link between farmers and end users of cassava-based products is the key for success of this project. The primary risk to this proposal relates to the need to identify a suitable private sector partner to take the lead in developing the medium-scale processing factory, and the need to ensure access to non CPHP funding sources in the form of venture capital and DFID's Business Linkage Challenge Fund (BLCF).

#### **Annex IV.**

##### **Feedback on the process from collaborating institution(s) and farmers (where appropriate)**

The PER report is being circulated in draft form to all partner institutions with the request that they provide feedback on their experience of project R7418.



## Annex V.

### List of publications

#### Publications:

DZIEDZOAVE, N. T., GRAFFHAM, A. J., MENSAH, B. A. AND GYATO, C. (2002) Use of cassava flour in paperboard adhesives. Proceedings of the 12<sup>th</sup> Symposium of the International Society for Tropical Root Crops. Tskuba Science City, Japan. 10-16 September 2000. Pages 95-99.

DZIEDZOAVE, N. T., GRAFFHAM, A. J. AND DEGRAFT-YARTEY, J. W. (2000) Preliminary evaluation of cassava flour as an extender for urea formaldehyde glues. *Paper presented at the 3<sup>rd</sup> International Meeting on Tropical Tuber Crops*, Central Tuber Crop Research Institute, Kerala, India. 19 January – 22 January 2000. [abstract] English. 9 pp.

HAMMOND, T. K., AYERNOR, G. S. AND GRAFFHAM, A. J. (2001). Basic conditions for production of sugar syrup from cassava flour by use of rice malt. *African Journal of Science and Technology*. In Press.

HAMMOND, T. K., AYERNOR, G. S. AND GRAFFHAM, A. J. (2001). The combination of rice malt and amyloglucosidase for the production of sugar syrup from cassava flour. *African Journal of Science and Technology*. In Press.

#### Internal Reports:

AIDOO, P. A., AND LARTTEY, P. (2001) Report on an awareness seminar on expanded markets for locally produced cassava flour in Ghana. GNAT Hall, Kumasi, Ghana 1st February, 2001. National Board for Small Scale Industries. Languages of presentation: English and Akan: 71 participants. 14 pp.

BLAY, D., LARWEH, P., DZIEDZOAVE, N. AND HAMMOND, T. (2000) Techno-economic assessment of existing markets for sugars and industrial alcohols. Food Research Institute, Accra, Ghana. 16 pp.

BOATENG, E. (2002). Business plan on village level cassava chip producing enterprise. National Board for Small-Scale Industries, Accra, Ghana. 19 pp.

BOATENG, E. (2002). Business plan on village level integrated cassava chip and flour producing enterprise. National Board for Small-Scale Industries, Accra, Ghana. 17 pp.

BOATENG, E. (2002). Business plan on urban level high quality cassava flour producing enterprise. National Board for Small-Scale Industries, Accra, Ghana. 17 pp.

BOATENG, E. (2000) Identification of commercial stakeholders in Accra, Tema, Kumasi and Takoradi. National Board for Small-Scale Industries, Accra, Ghana. 8 pp.

BOATENG, E. AND TAMAKLOE, M. (2002). Comparative analysis in the utilisation of cassava flour and wheat flour in the production of different bakery products. National Board for Small-Scale Industries, Accra, Ghana. 18 pp.

DZIEDZOAVE, N. T. (2001). Optimisation of procedures for conversion of cassava flour into glucose syrups by plant enzymes. PhD Transfer Report. University of Greenwich, October 2001. 79 pp.

DZIEDZOAVE, N. (2000) Introduction and literature review (sugar syrups). Food Research Institute, Accra, Ghana. 38 pp.

DZIEDZOAVE, N. T., GYATO, C., LARWERH, P., KRAMPAH, L., ADUKO., M. AND FIASIDEY. (2000) A participatory rapid appraisal of the status of cassava and various cereals in Watro – A farming community in the Atebubu District of the Brong Ahafo Region of Ghana. Food Research Institute and Ministry of Food and Agriculture, Accra, Ghana. 39pp. (Internal Report)

GRAFFHAM, A. J., AND DZIEDZOAVE, N. T. (1999) Rapid surveys of market opportunities for cassava. Natural Resources Institute, Chatham. Kent. UK. 8 pp. (Internal Report)

HAMMOND, T. K. (2001) Factors affecting the production of fermentable sugars from cassava flour by the use of rice malt and/or commercial enzymes. MPhil Thesis, Department of Nutrition and Food Science, University of Ghana, Legon, Ghana. 178 pp.

HAMMOND, T. K. (2000) Factors affecting the yield of fermentable sugars and alcohol from cassava flour by use of rice malt and commercial enzymes. University of Ghana, Accra, Ghana. 5 pp.

KOOMSON, J.G., AND YANKEY, D. F. (2001) Report on an awareness seminar on expanded markets for locally produced cassava flour in Ghana. Takoradi Beach Hotel, Takoradi, Ghana 18<sup>th</sup> January, 2001. National Board for Small Scale Industries. 62 participants. 20 pp.

KRAMPA, I., ADDUCE, M., FIASIDEY, P. AND WILSON, G. (2001) A participatory rapid appraisal of wheat-cassava flour composite in the bakery and confectionery industry in Atebubu District of the Brong Ahafo Region of Ghana. Ministry of Food and Agriculture, Sunyani, Ghana. 20 pp.

QUAYE, M., AMELEKE, G. AND DZIEDZOAVE, N. T. (2002) Economic feasibility of maltose production in Ghana. Food Research Institute, Accra, Ghana. 49 pp.

QUAYE, M., AND AMELEKE, G. (2001) Market opportunities for cassava flour in Ghana. Food Research Institute, Accra, Ghana. 20 pp.

STERKENBURG, D. B. (1999) Enzymatic breakdown of cassava starch. Optimisation of conditions for the use of extracts of germinating maize seedlings for hydrolysis of cassava starch. September – December 1999. Natural Resources Institute, Chatham. Kent. UK. 30 pp. (Internal Report).

#### **Other Dissemination of Results:**

NBSSI collaborates with other agencies. NBSSI News Volume 1, Number 7 December 2001 page 4.

Workshop on uses of cassava composite flour. NBSSI News Volume 1, Number 7 December 2001, page 17.

News feature on CPHP awareness seminar on expanded markets for locally produced cassava flour held in Accra on 17<sup>th</sup> May 2001. TV3, Ghana. 17<sup>th</sup> May 2001 (TV Programme).

News feature on CPHP awareness seminar on expanded markets for locally produced cassava flour held in Accra on 17<sup>th</sup> May 2001. GBC, Ghana. 17<sup>th</sup> May 2001 (Radio Programme).

Research feature: Expanded markets for cassava. Interview with Mr Nanam Tay Dziedzoave following the CPHP awareness seminar held in Kumasi on February 1<sup>st</sup> 2001. One hour feature on Radio Unvers 105.7 FM, Accra, Ghana, Monday 19<sup>th</sup> February 2001 (Radio Programme).

News feature on CPHP awareness seminar on expanded markets for locally produced cassava flour, held at Kumasi on 1st February 2001. Ghana Broadcasting Corporation (GBC), broadcast nationally via local FM radio stations. Thursday 1<sup>st</sup> February 2001 (Radio Programme).

News feature on CPHP awareness seminar on expanded markets for locally produced cassava flour, held at Kumasi on 1st February 2001. Joy FM, Kumasi. Thursday 1<sup>st</sup> February 2001 (Radio Programme).

News features on CPHP awareness seminar on expanded markets for locally produced cassava flour, held at Kumasi on 1st February 2001. Ghana Television (GTV). Monday 5<sup>th</sup> February 2001 and Saturday 10<sup>th</sup> February 2001 (TV Programme).

News features on CPHP awareness seminar on expanded markets for locally produced cassava flour, held at Kumasi on 1st February 2001. TV3, Ghana. Friday 2<sup>nd</sup> February 2001 and Saturday 3<sup>rd</sup> February 2001 (TV Programme).

News feature on CPHP awareness seminar on expanded markets for locally produced cassava flour, held at Takoradi on 18<sup>th</sup> January 2001. Ghana Broadcasting Corporation (GBC), broadcast nationally via local FM radio stations. Thursday 18<sup>th</sup> January 2001 (Radio Programme).

Seminar to promote use of cassava ends at Takoradi. Report of a CPHP awareness seminar on expanded markets for locally produced cassava flour, held at Takoradi on 18<sup>th</sup> January 2001. Daily Graphic. Monday 22<sup>nd</sup> January 2001 (Newspaper Article).

News features on CPHP awareness seminar on expanded markets for locally produced cassava flour, held at Takoradi on 18<sup>th</sup> January 2001. Ghana Television (GTV). Saturday 20<sup>th</sup> January 2001 and Saturday 27<sup>th</sup> January 2001 (TV Programme).

News features on CPHP awareness seminar on expanded markets for locally produced cassava flour, held at Takoradi on 18<sup>th</sup> January 2001. TV3, Ghana. Friday 19<sup>th</sup> January 2001 and Saturday 20<sup>th</sup> January 2001 (TV Programme).

BOATENG, E. O., GRAFFHAM, A. J. AND DZIEDZOAVE, N. T. (2001). Awareness seminar on expanded markets for locally produced cassava flour held in Accra on

17<sup>th</sup> May 2001. [One Day Awareness Seminar for 60 representatives of potential end users of cassava flour in Accra and Tema.

DARKWA, N. A. (2001) Economics of paperboard production using cassava starch-based adhesives in Ghana. Paper presented at the CPHP awareness days held in Takoradi and Kumasi on 18<sup>th</sup> January and 1<sup>st</sup> February 2001 respectively. 4 pp.

DZIEDZOAVE, N. T., GRAFFHAM, A. J., WESTBY, A. AND PLAHAR, W. A. (2002). Comparative assessment of amyolytic and cellulolytic enzyme activity of malts prepared from tropical cereals. Prepared for submission to the Journal of the Science of Food and Agriculture (Undergoing internal editing).

DZIEDZOAVE, N. T., GRAFFHAM, A. J., WESTBY, A. PLAHAR, W. A. AND NKROMA, K. (2002). Effect of gibberellic acid (GA<sub>3</sub>) and matting on amyolytic enzyme development in selected Ghanaian varieties of rice (*Oryzae* sp). Prepared for submission to the Journal of the Science of Food and Agriculture (Undergoing internal editing).

DZIEDZOAVE, N. T., KRAMPA, L. K. AND GRAFFHAM, A. J. (2002). Awareness and Training seminar for processors in Kokofu on production of sugar syrups from cassava flour. 7-8 February 2002 & 5-7 March 2002. [5 days of training (2+3) for 40 processors in Kokofu] [Akaan].

DZIEDZOAVE, N. T., GRAFFHAM, A. J., WESTBY, A. AND PLAHAR, W. A. (2001). Preliminary assessment of "kudeme" a traditional cassava based inoculum for amyolytic activities. Presented at the Fifth International Scientific Meeting of the Cassava Biotechnology Network. St Louis, Missouri, USA, 4-9 November 2001. Poster presentation.

GRAFFHAM, A. J. (2000) Expanded markets for cassava: Industrial options. Paper presented at the Brong Ahafo Regional Awareness Creation Forum of the Root and Tuber Improvement Programme (RTIP). Tropical Hotel, Sunyani, Ghana, Wednesday 21<sup>st</sup> June 2000. Languages of presentation: English and Akan. 85 participants. 8 pp.

JETUAH, F. K. (2001) Use of cassava flour-based adhesives for plywood and paperboard production. Paper presented at the CPHP awareness days held in Takoradi and Kumasi on 18<sup>th</sup> January and 1<sup>st</sup> February 2001 respectively. 4 pp.

KRAMPA, L. K. AND WILSON, A. (2001). Training seminar for bakers in Kwame Danso on using cassava flour in bakery products. 16-19 October 2001. [4 day training seminar for 24 bakers from Kwame Danso] [Akaan].

KRAMPA, L. K. AND WILSON, A. (2001). Training seminar for bakers in Atebubu & Prang on using cassava flour in bakery products. 11-14 September 2001. [4 day training seminar for 50 bakers from Atebubu & Prang] [Akaan].

KRAMPA, L. K. AND WILSON, A. (2001). Cassava flour in bakery products: A practical guide. 1000 copies Ministry of Food & Agriculture, Brong Ahafo, Sunyani, Ghana. 12 pp [Manual in English]

WESTBY, A., WHITE, J., NGENDELLO, T. OYEWOLE, O., GRAFFHAM, A. AND VAN OIRSCHOT, Q. (2001). Approaches for the development of small-scale cassava processing and local food industries that meet the needs of the poor.

Presented at the 8<sup>th</sup> triennial symposium of the International Society for Tropical Root Crops-Africa Branch. 12-16 November 2001.



## Annex VI.

### A catalogue of data sets and their location

Sets of original data are held at the partner institutions responsible for the major share of the work in Ghana. The Natural Resources Institute in the United Kingdom and Food Research Institute in Ghana hold master sets of data for the project. The individual holdings of data sets are as follows:

#### **Natural Resources Institute**

- Master set of data for the project
- PhD data for Mr Nanam Dziedzoave
- Application of expanded markets approach in Uganda

#### **Food Research Institute**

- Master set of data for the project
- Sugar syrups (FRI component)
- HQCF (FRI component)
- Paperboard & Plywood glues (FRI component)
- Market development

#### **University of Ghana (Department of Nutrition and Food Science)**

- Sugar syrups (UoG component)
- HQCF (UoG component)
- Industrial alcohol
- MPhil thesis – J. Ababio
- MPhil thesis – T. Hammond
- MPhil thesis – C. Ocloo

#### **National Board for Small Scale Industries**

- Identification of private sector partners
- Response to awareness seminars and wider media dissemination
- Business plans
- Cost benefit analysis for cassava flour in bakery products
- Production and user manuals for HQCF & cassava-based products

#### **Forestry Research Institute of Ghana**

- Paperboard Adhesives (FORIG component)
- HQCF as an extender for plywood glues
- Application of natural tree resins in combination with HQCF to reduce consumption of urea and phenol formaldehyde resins in plywood

#### **Ministry of Food and Agriculture (Brong Ahafo Region)**

- PRA data for Watro & Kokofu villages
- PRA data for bakers in Atebubu & Seni Districts
- Training of rural bakers
- Training of processors in Watro & Kokofu
- Pictures, recipe formulations & copies of rural bakers manual