INDUSTRIAL MARKETS FOR STARCH-BASED PRODUCTS: AN ASSESSMENT OF THE INDUSTRIAL POTENTIAL FOR CASSAVA IN UGANDA

Andrew Graffham[1]
Uli Kleih[1]
John Jagwe[2]
Jane Nabawanuka[3]
Kelly Wanda[2]
Patrick Kalunda[3]
George Ntibarikure[2]

Natural Resources Institute (NRI)[1]
FOODNET / International Institute of Tropical Agriculture (IITA)[2]
Kawanda Agricultural Research Institute (KARI)[3]

November 2000

CONTENTS

LIST OF TABLES

ABBREVIATIONS

ATM	African Textile Mill (Mbale, Uganda)
CIF	Carriage and Insurance Free
CPC	Corn Products Corporation (Kenya)
CPHP	Crop-Post Harvest Programme
DFID	Department for International Development
FOB	Free on Board
GDP	Gross Domestic Product
GoU	Government of Uganda
IITA	International Institute for Tropical Agriculture
KARI	Kawanda Agricultural Research Institute
NARO	National Agricultural Research Institute
NMS	Native Maize Starch
NRI	Natural Resources Institute
RS	Rectified Spirit (96% ethyl alcohol)
SBA	Starch-Based Adhesive
UMA	Uganda Manufacturers Association

ACKNOWLEDGEMENTS

Inputs made by members of staff from the Natural Resources Institute (NRI) of the United Kingdom (Dr Andrew Graffham and Mr Uli Kleih) were funded by the Crop-Post Harvest Programme (CPHP) of the Department for International Development (DFID) of the United Kingdom.

Inputs made by members of staff from FOODNET at the International Institute for Tropical Agriculture (IITA) in Kampala (Mr John Jagwe, Mr Kelly Wanda and Mr George Ntibarikure) were funded by the United States Aid Programme (USAID).

Inputs made by members of staff from the Kawanda Agricultural Research Institute (KARI) of the National Agricultural Research Organisation (NARO) of the Government of Uganda (Mr Patrick Kalunda and Ms Jane Nabawanuka) were funded by the Bilateral Programme of the Department for International Development (DFID) in Kampala.

Exchange rate (November 2000): US$1 = 1,900 Ugandan Shillings
ST£1 = 2,500 Ugandan Shillings

Note: For the sake of convenience all prices in this report are quoted in US Dollars. Prices in Ugandan Shillings were converted to US Dollars using the exchange rate given above.

SUMMARY

This report presents research into the current state of the Ugandan market for starch, starch-based adhesives and cassava flour for industrial use, and provides an assessment of the potential for locally made cassava-based products to replace existing raw materials derived from starch.

KEY FINDINGS

- The total market for starch-based products in Uganda is 580 tonnes per annum, this market can be broken down into starch (64%), cassava flour (28%) and starch-based adhesive for paperboard (8%).

- The market for starch is dominated by native maize starch, mainly imported from Kenya and South Africa. Modified starches are not important in the market, accounting for 0.07% of total demand. The majority of imported starch is used by the pharmaceutical industry (53.6%) followed by paperboard (32.5%), food processing (13.5%) and commercial laundries (0.4%).

- Prices for starch vary according to product grade. Technical grade starch costs between US$470-500 per tonne delivered to factory gate. Food grade starch ranges between US$545-631 per tonne delivered to factory gate, and pharmaceutical grade starch costs between US$800-1,100 per tonne delivered to factory gate.

- Locally made cassava flour is used as a substitute for imported starch by three out of six plywood, paperboard and textile factories in Uganda. These industries consume 216 tonnes of cassava flour per annum, and potential exists for a 33% increase in demand for cassava flour by 2005. However, industrial demand for cassava flour accounts for 0.09% of cassava flour production in Uganda. The majority of cassava flour is used as food.

- Cassava chips have the potential to partially replace (10%) maize/maize bran in animal feed rations. High-quality cassava flour has potential to partially replace (10%) wheat flour in bread and biscuits, and to completely replace imported starches and flours in plywood, paperboard and textile manufacture.

- Cassava chips in animal feed is the sector with most potential for realisation with the next 5 years. The market is relatively large (equivalent to 18,750 tonnes of fresh cassava roots per annum). The technology for production is quite simple and well suited to rural areas, and quality specifications should be relatively easy to meet.

- The livestock feed industry has expressed interest in uptake of cassava as a feed ingredient, if successful field trials can be made, and reliable supplies of cassava ensured.

- High-quality cassava flour in bread is an attractive area, with a market size equivalent to 26,400 tonnes of fresh cassava roots per annum. Representatives of the bakery industry expressed strong interest in testing cassava flour, as a means of reducing production costs. However, problems with gluten sensitivity, and consumer acceptability remain as serious concerns that could hinder or prevent realisation of this opportunity.

- High-quality cassava flour can readily replace imported materials in paperboard, textile and plywood manufacture and could replace 10% of wheat flour in the manufacture of biscuits. These markets are all small in size, with a total potential demand equivalent to 1,594 tonnes of fresh cassava roots per annum. They could offer suitable outlets for small groups of processors, but are too small to have any real impact on supply and demand for cassava in Uganda.

- The total potential demand for cassava as an industrial commodity is approximately 46,744 tonnes of fresh cassava roots per annum, which accounts for only 2% of the annual production of cassava in Uganda.

- There appears to be no potential for production of starch (either cassava or maize) in Uganda, as the internal market size is too small to provide scope for recovery of the investment cost (US$2 million for a factory producing 3,000 tonnes of native starch per annum). Surplus production might be exported to other countries in the region but investors should expect stiff competition from rival concerns in Kenya and South Africa.

- Existing linkages between the private sector and research organisations in Uganda are very limited. In discussions with representatives of the food and livestock feed industries it became apparent that industry is unaware of the wealth of research findings available from local and international researchers.

RECOMMENDATIONS

Although the potential for industrial use of cassava in Uganda is relatively small, it could nonetheless offer stable markets for cassava producers and processors of dried cassava/flour in the area at the eastern end of Uganda's industrial corridor (Pallisa, Kumi, Kapchorwa, Mbale, Tororo and Busia Districts). Income from realisation of industrial markets for cassava can contribute towards the livelihoods of farmers and rural processors, and provide the means for financing education, healthcare or other income generating activities (Graffham, 2000 and Dziedzoave, *et al.*, 2000).

The present survey has identified cassava in animal feed and bakery products (bread and biscuits) as the sectors with most potential, although the smaller markets of plywood, paperboard and textiles should not be ignored. However, to realise these opportunities a number of issues need to be dealt with, we therefore recommend the following:

- Funds should be sought to enable dissemination of information about the potential for cassava chips and high-quality cassava flour in animal feeds and bakery products through awareness seminars and practical workshops for the various stake-holders (especially private sector) in the target industries. It would be highly desirable to work closely with the Ugandan Livestock Feed Association and the Association of Ugandan Millers and Bakers in developing the awareness campaign.

- It would be highly desirable to create an opportunity for key representatives of the private sector involved in development of links with rural processors and potential processors to visit established cassava-based agro-industries in South and South East Asia, to obtain first hand experience of the successful strategies for development of industrial uses of cassava, and the technologies available.

- An integrated approach should be adopted, whereby research organisations form closer links with private sector partners to examine issues of economic and technical feasibility of exploiting each opportunity, preparation of business plans, and development of closer links between the urban end user of the product and rural producer of fresh or dried cassava.

- To carry out research to identify the areas of Uganda that have the greatest potential to provide steady supplies of cassava for industrial use. This work would probably focus on the districts mentioned above, and should take into account issues of availability, price, competition from traditional markets, potential for surplus production, access to roads and proximity to industrial areas.

- Market surveys are required of existing and potential markets for starch-based raw materials in Kenya, Tanzania and Rwanda. Emphasis should be placed on characterisation of existing markets, and determination of the potential for cassava to replace existing materials. Ugandan manufacturers would be interested in an assessment of the potential for regional exports of cassava-based products from Uganda.

- There is a need to sensitise farmers about the importance of producing dried cassava of consistently high quality in order to meet the requirements of the potential end users. Farmers need to be trained and equipped with the necessary techniques for producing a high quality product. If necessary proven technology should be bought in from countries such as Ghana that already have experience of production of high-quality cassava products for industry under rural conditions.

- Quality assurance remains a key issue for realisation of any of the industrial opportunities for cassava. Realistic standards need to be defined, and mechanisms put in place for monitoring end product quality, so as to ensure that markets are not spoiled through errors resulting from ignorance or wilful adulteration of products. Standards can be developed in collaboration with industry, and the producers of the products, but the monitoring and enforcement of quality assurance should be handled by an independent body. In the longer-term this will probably become the responsibility of the Ugandan National Bureau of Standards, but at the early stages of development it seems likely that an organisation such as IITA could become involved. Involvement by IITA in this process must only occur with the full approval and collaboration of all stakeholders, and must be carefully organised to ensure impartiality and transparency in dealing with quality assurance in the market chain.

INTRODUCTION

In the light of a rapidly growing economy and efforts to modernise Uganda's agricultural sector, agro-industries have the potential for an increasingly important role in the development of the nation. Given its importance in the countries farming system, cassava has technical potential as a raw material for several agro-industrial products, such as flours, animal feed and starch. However, these markets have not been thoroughly investigated.

The current work forms part of a larger study of the markets for cassava products in Uganda. The first phase of this work examined issues of cassava production, supply and traditional markets (Collinson, *et al.*, 2000). The previous work should be considered as an integral part of the current study, as issues of cassava production and traditional markets will determine the potential for success of cassava as an industrial commodity.

To be successful as an industrial raw material cassava supplies must be sufficient to meet the needs of both the traditional food markets and the new industrial markets. Furthermore, this supply must be reliable and thus must take account of potential fluctuations in supply and demand within the traditional food markets. During the year 2000, serious drought conditions in Kenya and Eastern Uganda has increased demand for cassava as a food security crop, and pushed up prices for both fresh and dried cassava in Uganda.

OBJECTIVES OF THE STUDY

The objective of the current study was to make a rapid but detailed investigation of existing industrial markets for starch-based products in Uganda (starch, flour, adhesives and alcohol), and to assess the potential for cassava-based products to replace existing materials. The following industrial sectors were chosen as being of greatest importance for the current study:

Animal feed, Plywood, Paperboard, Textiles, Food industry, Pharmaceuticals, Laundry starch, Soap and detergent powders and Industrial alcohol.

Survey activities were concentrated in towns that contain the majority of Uganda's industries. These are Kampala, Lugazi, Jinja, Mbale and Tororo. These towns form a belt around the northern shore of Lake Victoria, and are well connected, being situated along (or close to) the main road from Kampala to the Kenyan border.

METHODOLOGY

The research design focused on a sub-sector approach, while the technique involved conducting informal interviews with key informants and direct observation of the critical stages in the production-transformation line. Although the survey was about potential industrial markets for cassava,

Sound secondary data sources were relied upon whenever possible. Following a literature review and interviews with key private sector associations, a list of potential firms was compiled and preliminary visits carried out to explain the objective of the survey, acquaint researchers with actual industrial concerns and also book appointments for the primary visits.

The sample was purposively selected to include respondents from each of the relevant categories identified during the literature review as potential raw material users. Rather that concentrating on numbers, the focus was placed on contacting key firms in the industry in order to obtain a more representative sample.

For each industry to be visited, questions (guidelines) focusing on key production and marketing activities were developed. The semi-structured informal interview guidelines were not written up in the form of a formal questionnaire. They were rather drawn up as checklists of key issues and topics. Once the survey teams were used to the detailed questions of the original checklist (approx. 7 pages), a shorter version of the latter (i.e. 1 – 2 pages max.) was found useful to stimulate a free-flowing discussion with members of the industries.

Given the size of the research team (i.e seven researchers from three different organisations), the latter was divided into three sub-teams comprising two to three members. Interviews were conducted on an informal basis by the different sub-teams of researchers. It was essential that each of the teams included at least a technologist and an economist. After each interview the teams compiled a report about each of the industries visited using the checklist to make sure no issue had been overlooked.

Respondents were contacted at their places of work. Researchers were careful to identify themselves and to explain the purpose of their visit. Given the seniority of most of the business managers interviewed, it was found members of the research teams Also, before leaving researchers inquired from their respondents whether any of the information divulged was of a sensitive nature so as to be edited from the public report.

Data were recorded either in field notebooks or directly in the checklist, sometimes during interviews, but more often soon afterward. It was felt important that note-taking should not inhibit a free flow of discussion. This effort to keep the interviews informal seemed to encourage frankness on the part of the respondents.

For far away firms, where bookings could not be made by telephone due to various reasons, visits were nevertheless made. This form of “cold-calling” was generally accepted, and useful data was obtained. However, there is a danger that without prior appointment key individuals might be missed. In this case, another visit is obligatory.

Responses from each interview were carefully compared with the responses from other interviews carried out with firms in the same category. This approach was conducted through meetings of the entire research team, which were designed to:

- Ensure that all the collected data had been summarised.
- Identify gaps in the existing information.
- Start forming hypotheses about constraints and opportunities within the marketing system.
- Assess the progress of the survey.
- And design a follow-up of the fieldwork where necessary.

The researchers also used the team meetings to refine their understanding of the roles, responsibilities and links within the production and manufacturing business.

Box: Summary of Steps involved in Industrial Market Survey

- Formulation of survey objectives
- Selection of multi-disciplinary team comprising technical and economic disciplines
- Survey design, led by team leader in close collaboration with other team members
- Identification and study of secondary literature
- Contact of business associations
- Selection of industries to be visited
- Design of interview guidelines and checklists
- Contact of industries in order to book appointments
- Visits to industries by sub-teams; "Cold-calling" where bookings could not be made; Note-taking during and after the visits; Regular meetings by entire research team during the course of the survey
- Meeting by entire team to discuss findings by industrial sector, and recommendations
- Drafting of report. Sub-sections to be covered by sub-teams most familiar with industries concerned
- Meeting by entire team to discuss draft report assembled by team leader. Close e-mail contact if meetings are not possible
- Finalisation of report by team leader

INDUSTRIAL DEVELOPMENT IN UGANDA

Following the introduction of a reform programme by GoU in the late 1980s, the Ugandan economy experienced substantial growth during the 1990s. Most progress was achieved between 1993 and 1997, when the structural reforms, including macro-economic stabilisation and trade liberalisation, reached their peak (The East African, Nov. 20 – 26, 2000). According to the latter source, on average, economic growth was 6% during the last decade.

Uganda's economy is largely based on agriculture, which contributes 45% of the country's GDP (1997), and 95% of the export revenue (UMA, 1999/2000). The sector is dominated by small-holder farming. Coffee is by far the most important earner of foreign exchange and a major source of income in rural areas. The agricultural sector is considered to have substantial potential for growth and investment.

Although rapid growth has been experienced by the manufacturing sector during the 1990s (e.g. 17%in 1997), due to historic reasons, the latter is still small in size (UMA, 1999/2000). Nevertheless, industry is an important source of income and employment, contributing 16% of the GDP. Manufacturing activities are concentrated in agro-processing, such as food, sugar, tobacco, and cotton.

Improvements in the macro-economic and legislative environment provide an incentive for both local and foreign investors. At the same time, in spite of improved investment conditions, the relatively small size of the domestic market represents a constraint to industrial development in Uganda. Although there is some export potential within the region, domestic manufacturers also face competition from imports produced in Kenya, South Africa, and outside the continent.

The challenge is to identify industries that have a comparative advantage in supplying both domestic and regional markets. Economic development and poverty reduction will ultimately depend to a large extent on the creation of employment outside the primary sector. One of the entry points for increased industrial growth is better utilisation of the country's abundant natural resources. This study looks at how agro-industries can benefit from cassava, which is considered to be one of the crops with substantial production potential in Uganda.

OVERVIEW OF THE UGANDAN MARKET FOR STARCH, STARCH-BASED ADHESIVES AND CASSAVA FLOUR FOR INDUSTRIAL USE (NOVEMBER 2000)

The Ugandan market for starch, starch-based adhesives and cassava flour for industrial use in Uganda is summarised in table 1. The total market size in November 2000 was found to be only 580 tonnes of starch, starch-based adhesive (SBA) and cassava flour for. This is much lower than the estimate of 1,000-1,500 tonnes of starch per annum given in an earlier survey of marketing opportunities for cassava and sweet potato starch and flour in Uganda (IITA, 1999). This can be explained in part by the failure of Nytil Picfare (textile manufacturer) who formerly consumed 240 tonnes of starch per annum.

Native starch is the most important of the materials accounting for 64% of the total market for starch-based materials. Locally made cassava flour accounts for 28% of the market, and imported SBA's account for the remaining 8%.

The demand for starch is dominated by native maize starch imported mainly from Kenya and South Africa. Modified starch was only found in the laundry industry, where 250kg of soluble starch are used per annum. Two other companies reported carrying out trials with modified starches in processed foods, but said that activities were discontinued because customers did not like the new products. The Ugandan market for starch is summarised in table 2. The market is dominated by the pharmaceutical industry (~54%) who use very high quality native maize starch purchased at a premium rate (table 1).

Table 2. Market for starch in Uganda (November 2000)

Sector	**Quantity tonnes per annum**	**Market share %**
Pharmaceutical	**198**	**53.6%**
Paperboard	**120**	**32.5%**
Processed Food	**50**	**13.5%**
Laundry	**1**	**0.4%**
Total:	**369**	**100%**

Imported starch and SBA's are expensive, and it comes as no surprise to find that Ugandan manufacturers are searching for cheaper locally made alternatives. The pharmaceutical and food sectors have no alternative but to continue importing starch, because of the very high quality specifications required for their products, which link to issues of food safety and standards set for medicines intended for human consumption. According to industry, the demand for starch in Uganda should increase by 13% in period from 2000-2005.

The plywood, paperboard and textile industries have greater flexibility in choosing raw materials as their products are not bound by regulations applied to food and medicines. The industries in Uganda have successfully adopted locally made cassava flour as an alternative to imported starch, and two of the paperboard companies are interested in preparing their own SBA formulations using cassava flour instead of starch. If the plans of these industries are successful, consumption of imported SBA should decrease by 8% over the next 5 years, and demand for cassava flour for industrial use should increase by 33%.

The potential increase in demand for cassava flour by industry appears impressive, but the predicted industrial demand of 242 tonnes of cassava flour (726 tonnes of fresh roots) per annum, is negligible when compared to figures for human consumption of cassava flour in Uganda. According to Collinson, *et al.*, (2000), using data from the Ugandan National Household Survey, Ugandans consumed approximately 180,000 tonnes of cassava flour in 1997 (equivalent to 540,000 tonnes of fresh cassava roots). On this basis industrial demand for cassava flour currently accounts for just 0.09% of production, with potential to increase to 0.13% of annual production by 2005.

Table 1. Ugandan market for starch, starch-based adhesives and cassava flour for industrial use (November 2000)

Commodity and Industry	Raw material	Existing market tonnes per annum (2000)	Potential market by 2005*	Import cost US$ per tonne delivered to factory gate and grade of starch
Imported Starch				
Pharmacy	Imported native maize starch (NMS)	198 tonnes of NMS	228 tonnes of NMS	US$800-1,100 per tonne Pharmaceutical grade
Paperboard	Imported (NMS)	120 tonnes of NMS	138 tonnes of NMS	US$470-500 per tonne Technical grade
Processed foods	Imported (NMS)	50 tonnes of NMS	58 tonnes of NMS	US$545-631 per tonne Food grade
Laundry starch	Imported NMS and soluble starch	1 tonne (0.75 tonnes of NMS) and 0.25 tonnes of soluble starch	1.2 tonnes of NMS and soluble starch	US$500 per tonne Technical grade
Total requirement for starch in Uganda:		**369 tonnes**	**425 tonnes**	
Imported Starch-Based Adhesives (SBA)				
Paperboard	Imported native maize starch-based adhesive	49 tonnes of SBA	41 tonnes	US$800 per tonne
Total requirement for SBA's in Uganda:		**49 tonnes**	**41 tonnes**	
Locally made Cassava Flour				
Plywood	Locally made cassava flour	72 tonnes locally made cassava flour	96 tonnes of locally made cassava flour	US$184-237 per tonne
Paperboard	Locally made cassava flour	54 tonnes of locally made cassava flour	110 tonnes of locally made cassava flour	US$153-237 per tonne
Textiles	Locally made cassava flour	36 tonnes locally made cassava flour	36 tonnes locally made cassava flour	US$153-158 per tonne
Total requirement for cassava flour in Uganda:		**162 tonnes**	**242 tonnes**	
Total requirement for starches, SBA's and cassava flour		**580 tonnes**	**708 tonnes**	

* Estimated growth based on industry predictions.

OVERVIEW OF POTENTIAL FOR INDUSTRIAL UTILISATION OF CASSAVA IN UGANDA

This section provides an overview of the potential for cassava in a range of industrial sectors in Uganda, a summary of the findings from the survey is given in table 3. On the basis of market size and quality requirements the various sectors can be divided into those with potential for realisation in the near future (<5 years), those with potential in the medium to long-term (>5 years) and those with no potential for realisation in the foreseeable future (>10 years). An overview of each of these groups is given below.

Overall, the two sectors with the most potential for utilisation of cassava are animal feed and bakery products (bread & biscuits) which account for 98% of the potential annual demand for cassava (45,750 tonnes of fresh cassava) by Ugandan industry. The remaining sectors (plywood, paperboard & textiles) account for just 2% of the potential annual demand (994 tonnes of fresh cassava) for cassava by industry. Although cassava is already in use in these sectors and accounts for 49% of the starch-based raw materials used (162 tonnes of cassava flour per annum), there appears to be little chance for expansion of these sectors in the near future, and as such demand for cassava-based products is unlikely to increase significantly.

SECTORS WITH POTENTIAL TO UTILISE CASSAVA IN THE NEAR FUTURE (<5 YEARS)

Animal feed

Research in many parts of the world has demonstrated that dried cassava can substitute for part of the cereal-based energy component of livestock feed rations.

The major factors that could influence the realisation of this opportunity are:

- The animal feed industry in Uganda requires reasonable quantities of cassava (~19,000 tonnes of fresh cassava) per annum.
- Animal feeds have relatively low quality specifications.
- Little investment is required to realise the opportunity.
- The long-term prospects of the Ugandan livestock industry appear favourable.
- Potential for export of dried cassava to similar industries in neighbouring countries.

Table 3. Industrial options for high-grade cassava flour in Uganda.

Industry	Current raw material	Potential locally produced cassava-based alternative	Existing market (tonnes per annum)	Market potential (tonnes of fresh cassava per annum)
Animal feed	Maize, maize, wheat and rice bran	Cassava chips	37,500 tonnes of cereal based carbohydrates	18,750 tonnes
Plywood	Locally made cassava flour	Cassava flour	72 tonnes locally made cassava flour	216 tonnes
Paperboard	Imported maize starch based adhesive, imported native maize starch (NMS) and cassava flour	Starch based adhesive (SBA) made from high-grade cassava flour	223 tonnes of SBA including 54 tonnes of locally made cassava flour	670 tonnes
Textiles	Locally made cassava flour	Cassava flour	36 tonnes locally made cassava flour	108 tonnes
Bread	Imported wheat equivalents	High-grade cassava flour	88,000 tonnes imported wheat equivalents	26,400 tonnes*
Biscuits	Imported wheat equivalents	High-grade cassava flour	2,000 tonnes imported wheat equivalents	600 tonnes*
Processed foods (sauces)	Imported NMS	Cassava starch and cassava flour in sausages	50 tonnes of NMS	Very little potential
Pharmacy	Imported NMS	Cassava starch	198 tonnes of NMS	No potential
Industrial alcohol	Locally produced sugarcane molasses	Cassava derived sugar syrup	1 million litres of rectified spirit per annum	No potential
Laundry starch	Imported NMS and soluble starch	Cassava starch	1 tonne (0.75 tonnes of NMS) and 0.25 tonnes of soluble starch	No potential
Total market requirement (tonnes fresh cassava)				**46,744 tonnes**

* Assuming a 10% replacement of imported wheat equivalents with high-grade cassava flour.

Plywood, Paperboard and Textile industries
These three sectors have limited market potential in terms of size, but have the advantage that cassava flour is already accepted by many of the industries involved in these sectors.

The major factors that could influence the realisation of this opportunity are:

- Cassava flour is already accepted by industry.
- Industries have relatively low quality requirements in Uganda.
- Little investment is required to realise the opportunity.
- Potential for export of cassava flour to similar industries in neighbouring countries.

SECTORS WITH POTENTIAL TO UTILISE CASSAVA IN THE MEDIUM TO LONG-TERM (>5 YEARS)

Biscuits
Research in Ghana has demonstrated that high-quality cassava flour can be used to substitute for up to 35% of wheat flour in sweet dough biscuits without being detectable by urban consumers (Graffham, *et al*., 2000). If cassava flour is used at higher levels of substitution, consumers notice a reduction in golden colour of the biscuit, and lessening of wheaty flavour. At very high levels (>50% cassava flour) of substitution the biscuits develop a brittle crumbly texture which is not commercially acceptable.

The major factors that could influence the realisation of this opportunity are:

- Biscuits production is less gluten sensitive.
- Products should readily achieve consumer acceptability, if correct marketing approach is adopted.
- The downside of this opportunity is the limited size of the potential market (200 tonnes of cassava flour per annum).

Bread
Research in many parts of the world has demonstrated that high-quality cassava flour can be used to substitute for up to 10% of wheat flour in bread without being detectable by urban consumers. Higher levels of substitution are not advisable as consumers do not the product, which typically has a reduced loaf volume and heavy texture.

The major factors that could influence the realisation of this opportunity are:

- Relatively large market size (8,800 tonnes of cassava flour per annum).

- Ugandan bakery industry has expressed strong interest in cassava flour due to increasing cost of existing raw materials (wheat flour), and stiff competition with the industry.

SECTORS WITH NO POTENTIAL TO UTILISE CASSAVA IN THE FORESEEABLE FUTURE (>10 YEARS)

Starch

Starch is an important industrial commodity that finds applications in a wide range of industries. The largest consumers of starch and starch-based products in a industrialised country are textiles, paper and plywood, adhesives, processed foods and pharmaceuticals and cosmetics. Smaller amounts of starch are used in a wide range of other applications including fillers for explosives and biodegradable plastics.

In Uganda imported native maize starch, is used in the pharmaceutical, paperboard, processed foods and laundry sector. Starch-based adhesives (SBA) are used in paperboard manufacture. However, the total market for starch and SBA's (418 tonnes per annum) in Uganda is very small with only limited potential for growth (Table 1). A small-scale factory for production of 10 tonnes per day of maize or cassava starch will cost approximately US$2 million (price current in November 2000) to import and install in Uganda. This factory has the capacity to produce 3,000 tonnes of starch per annum, and would need to operate at 80% of capacity to ensure recovery of initial investment and profitability within 2-5 years (Graffham and Westby, 1998).

Thus a Ugandan starch factory would need to produce a minimum of 2,400 tonnes of starch per annum. The total demand for starch in Uganda would account for 17% of production. The remaining 1,982 tonnes (83%) would have to be exported to customers outside of Uganda. This might be achievable, but would be investors in starch manufacture should be aware that they will face stiff competition from other producers of starch in the region (Kenya and South Africa) and from the big international players who have a huge advantage in terms of economy of scale, and established market share.

In addition potential investors in starch production need to take account of the following key points before going ahead with proposals for establishing a starch factory (Graffham and Westby, 1998):

(i). ***Raw material supply and seasonality of supply.*** Starch factories require at least 20-40 tonnes of high quality dry maize or fresh cassava roots a day for a period of at least 100 days a year to be effective. To supply these demands the raw material has to be treated as a high value cash drop and grown on a large-scale. Reliability of supply could be a serious issue in an area where maize and cassava have always been perceived as staple and food security crops. To be effective starch factories need a long processing season with continuous supplies of raw material of constant quality. In many cases climatic problems reduce the season to between 4-6 months. Factories relying on sun drying face the additional difficulty of finding that the peak season for raw material availability often coincides with periods of wet and cloudy weather which are unsuitable for sun drying.

(ii). ***Road infrastructure.*** A good road infrastructure is required to ensure that cassava roots can reach the factory for processing within 12 hours of harvest. This factor can be obviated by using dry maize as the raw material.

(iii). ***Water supply.*** Starch factories require large amounts of water of good quality for processing. Process water should be free of solid particles, low in iron (<0.3mg ferrous ions/litre) and as soft as possible.

(iv). ***Power supply.*** Starch is a mechanised process so a reliable source of power needs to provided. This may have to be self contained as starch factories are likely to be situated in rural areas close to the cassava farms.

(v). ***Access to land.*** This is most important for traditional factories that require a large area for settling tanks and drying yards.

(vi). ***Availability of skilled labour.*** Modern and traditional starch factories have a relatively low labour requirement, but both require efficient management and the modern factories need highly skilled personnel both to operate and maintain the facility.

(vii). ***Choice of drying method.*** Sun drying will reduce costs but increase processing time and can only be used if the factory is situated in an area of low rainfall, high air temperatures and low humidity. Artificial drying may seem the obvious solution, but flash drying is the major cost burden of any modern factory both in terms of capital investment and running costs. To be economic a flash dryer must have a high loading for most of the year.

In the light of all of these factors, there appears to be little potential for starch manufacture in Uganda in the foreseeable future.

Sugar syrups

Sugar syrups are very important for the food, beverage and pharmaceutical industries. Some of the most popular products include high fructose syrup for the beverage industry, and liquid glucose for both food and pharmaceutical industries.
Starch is often used as a raw material for production of sugar syrups through controlled enzymatic hydrolysis. Simple processes result in a range of maltodextrins (breakdown products of starch), maltose and glucose. With greater process control starch can be almost completely degraded to produce glucose syrup. High fructose syrup is prepared by enzymatic isomerisation of glucose syrup.

Uganda has a reasonably large food and beverage industry which currently relies on glucose syrup (1,800 tonnes per annum) and crystalline sugar as raw materials but which could convert to high fructose syrup in the future. One pharmaceutical manufacturer is producing cough syrups in Uganda and consumes 160 tonnes of glucose and liquid glucose per annum. The glucose is imported from the Kenyan maize starch manufacturer Corn Products Corporation (CPC).

Although a market exists for sugar syrups, an essential prerequisite for production is a supply of cheap high quality starch, so this industry can only develop if conditions in Uganda become favourable for development of a Ugandan starch industry.

Industrial alcohol
Industrial alcohol can be prepared from glucose syrups derived from enzymatic breakdown of cassava starch or flour. Uganda has a reasonable capacity for production of industrial alcohol, but there is no potential for cassava in this area. The reasons for this are as follows:

- Ample supplies of existing cheap raw material for alcohol production (molasses);

- Process involving starch hydrolysis is more expensive than molasses-based process.

Industrial chemicals
The area of industrial chemicals is very large and is normally fed with feedstocks derived from the petrochemical industry. In the absence of petroleum and suitable sources of alcohol distilled from sugarcane, industrial alcohol prepared from starch can be used as the feed stock for production of a wide range of organic chemicals. However, the industrial chemicals sector in Uganda is very underdeveloped with little potential for growth in the medium-term and as such there is no potential for utilisation of cassava in this area.

Biodegradable plastics from starch
Increasing levels of pollution from durable polyurethane and polyethylene based films have provided the impetus for development of partially and fully degradable plastic films and mouldings. Partially degradable films using surface modified cassava starch have been developed and commercialised in India (Balagopalan , 2000). These films contain 40% cassava starch and 60% of low-density polyethylene polymer, and thus are partially degradable. In Thailand plastic films have been made from 100% cassava starch using a process known as annealing which enables starch polymers to be converted into a flexible sheet. This product is completely biodegradable, but high cost of production would appear to be the limiting factor in the process.

To manufacture these products, a country must have existing industrial capacity and research expertise in conventional petrochemical based plastics. In addition the country should have access to a low cost supply of native starch produced in country.

Uganda has neither of these attributes, and is unlikely to develop this level of industrial capacity, and thus there is no potential for cassava-based products in this area.

FINDINGS FROM THE INDUSTRIAL SURVEY WITH REFERENCE TO EXPERIENCES FROM OTHER COUNTRIES

ANIMAL FEED

Livestock production and demand for livestock products

Livestock production constitutes an important sub-sector of agricultural production in Uganda, currently contributing about 16% of total agricultural GDP (GoU, 1998). Most of the livestock production takes place on small farms. Grazing is the predominant mode of feeding of cattle (i.e. dairy and beef production). Large scale commercial ranches and dairy farms constitute only 5% of the cattle population (GoU, ibid). Pastoral production systems play an important role in some parts of the country. The vast majority of animals consists of indigenous breeds.

The situation with poultry production is similar, in that it is estimated that the commercial flock for the production of eggs and meat represents only about 14% of the total number of birds. Goats, pigs, and sheep production is almost exclusively based on indigenous breeds. Table 4 provides an overview of the total number of animals in the country.

Table 4. Estimated livestock population in Uganda (‘000s).

	1993	1994	1995	2000
Cattle				
Exotic & crossbred	196	208	221	295
Indigenous	4,398	4,530	4,666	5,409
Small Ruminants				
Goats	5,194	5,714	6,285	10,122
Sheep	883	927	974	1,243
Pigs				
Commercial	3.4	3.8	4.1	6.7
Indigenous	1,136	1,193	1,252	1,598
Poultry				
Commercial layers	597	657	722	1,163
Commercial broilers	1,274	1,402	1,542	2,483
Indigenous	17,390	17,912	18,449	21,388

Source: Agricultural Policy Secretariat

Table 5. Estimated production and demand for selected livestock products.

	Production	Demand	Self-sufficiency Ratio
Milk (available for human consumption, 000 litres)			
1995	282,810	431,727	0.66
2000	344,399	488,459	0.71
Beef (tonnes)			
1995	66,149	117,571	0.56
2000	77,336	133,021	0.58
Poultry (tonnes)			
1995	12,742	32,656	0.39
2000	16,358	36,951	0.44
Eggs (tonnes)			
1995	14,562	159,300	0.09
2000	20,955	180,233	0.12
Pork (tonnes)			
1995	13,193	18,187	0.73
2000	16,853	20,576	0.82

Source: Agricultural Policy Secretariat

A self-sufficiency ratio of less than 1.0 can be observed for all animal products in Table 5, indicating that demand exceeds supply. The production of goat meat and mutton is sufficient to cater for the demand. In light of demand for poultry, dairy, beef and pork still exceeding supply, it can be expected that production will continue to increase in the years to come. Given the growth rates of animal production experienced during the past decade, it is expected that domestic producers will be able to compete against imports. The driving forces behind the increase in demand are population growth, urbanisation, increased purchasing power, and changes in consumption habits.

Given that feeds and feeding are the most costly items in livestock production, the Animal Production Programme places emphasis on feed resource development and management. Cassava based animal feed rations can improve the availability of feeds and lower the costs in both commercial and small-scale production systems. The following sections will focus on the potential application of cassava in feed rations.

Feed use in Uganda

There are four main producers of livestock feeds in Uganda, namely Uganda Feed Ltd (i.e. NUVITA), Ugachick, Bulemezi, and Kagodo Feeds. The monthly feed output of these companies varies in the range of 600 – 1500 tonnes. In addition, there are a few medium scale producers such as Maganjo and many small-scale “backyard” feed mixers.

The annual production of the commercial feed millers is estimated at about 35,000 tonnes. It is estimated that the small-scale mixers produce another 40,000 tonnes. As a consequence the combined output of the formal and informal sectors is estimated at 75,000 tonnes of animal feed. Demand for poultry feed is particularly high before the main festivities such as Christmas and Easter, and for dairy feed during the dry season.

The bulk of the feeds are for poultry (i.e. about 90%). Within this category the largest amount is for layers, followed by broilers, growers, and chicks. Compared to poultry feeds, the amount of dairy feed is relatively small, and mostly produced by Uganda Feeds Ltd (i.e about 90% of commercial production).

The following illustrates the types of feeds produced by Uganda Feeds Ltd., who are the country’s largest producer:

Poultry: 60 – 70% (up to 75%)
- Layer mash: 35 – 40%
- Broilers: 6 – 15%
- Growers: 8 – 10%
- Chicks: 4 – 6%

Dairy: 20% (17 – 30%)
Piggery: 2 – 4%
Miscellaneous (Rabbit, dog food, etc): 4%

Concerns about the quality of feed, in particular that produced by small-scale mixers, have led to efforts to introduce a Feed Bill in Uganda. The latter is currently discussed by stakeholders in the industry including the larger feed millers, who expressed concerns that standards proposed apply to European conditions. For example, they feel moisture or energy levels requested would be difficult to achieve given the raw materials available. At present, there is only one company which has pelleting facilities.

The bulk of raw materials used in Ugandan animal feed consists of milling by-products such as maize bran, wheat bran, and rice bran. In addition, maize is also used as an energy source, however, it often consists of broken material. The amount of carbohydrate sources used in feed formulations varies between 50 – 55%, depending on the raw material and the formulation. The relatively low level of energy in feed concentrates is due to the lack of supply of cheap carbohydrate sources. For example the feed millers mentioned that the production of yellow maize was minimal. The use of cassava which can replace maize up to certain levels, has been discussed with the feed millers.

The main protein sources used include fish, and cakes from cottonseed and sunflower (i.e. by-products from local oil processing industries). Soybeans are recognised as a valuable source of protein, however there is only limited supply.

Prices (i.e. at factory gate) of some of the raw materials paid by the milling industry during the second half of 2000 are as follows:

Maize:	Shs220 – 300/kg
Maize bran:	Shs70 – 160/kg
Fish meal:	Shs450 – 600/kg
Cottonseed cake:	Shs150 – 250/kg
Sunflower cake:	Shs160 – 180/kg

Aside from feed additives, which are imported, the bulk of the raw material is available locally. Brans are by-products from the flour milling industries, and cakes from the oil mills. One company indicated imports of wheat bran from Kenya for the production of poultry feeds. Fish is available from the lakes (e.g. Lake Victoria, Lake Kyoga, Lake Albert). Concerns were expressed about future availability and quality of fish (i.e. *Mukene*). The introduction of stricter fishing standards (i.e. larger mesh size) could lead to a situation whereby only larger sized fish will be available, resulting in drying difficulties.

Apart from mills using their own by-products, the bulk of raw materials is supplied by traders. Outgrower schemes have been attempted but were not successful. Problems included drought, low yields, high prices offered elsewhere, and farmers selling to higher paying buyers.

The use of cassava in animal feed

During the survey carried out in the second half of 2000, no utilisation of cassava in animal feeds was observed. However, about eight years ago Uganda Feeds Ltd included small amounts of cassava in their feeds, when they were approached by cassava farmers who had produced a surplus. The utilisation of cassava was discontinued due to lack of a reliable supply.

It is expected that feed demand will increase in the long-term, owing to growing consumption of animal products. This is due to factors such as population increase, income increase, urbanisation, and changes in consumption patterns. This is likely to lead to a shortage of raw materials in the future. As a consequence, feed millers will search for alternative feed ingredients (i.e. carbohydrate and protein sources).

Cassava is an energy source well suited for animal feeds, as demonstrated by its utilisation in many countries. In 1994, about a quarter of the global cassava production was estimated to be used as an ingredient in pork, poultry, cattle, and fish feeds (IFAD/FAO, 2000). However, there are wide differences in utilisation between continents. In Africa and Asia, only about six percent of the cassava production is used for animal feed. In Latin America and the Caribbean feed utilisation is of the order of 47%, mainly due to high usage in Paraguay and Brazil. Until about 1990, Europe has been the engine of the growth of cassava utilisation in feed formulations. However, quantities of dried cassava mainly imported in the form of pellets from

Thailand, have decreased from 7 million tonnes in 1989 to 3.6 million tonnes in 1994 (ibid, 2000). This was mainly due to changes of the Common Agricultural Policy (CAP), resulting in lower prices of locally available feed grains.

Substantial amounts of research into cassava utilisation in feed rations have been carried out in Africa during the last three decades (Hahn, *et al.*, 1992; Lekule, 2000). The following tables illustrate the results of research undertaken in Ivory Coast into the use of cassava in broiler rations.

Table 6. Composition of experimental broiler rations in Ivory Coast

	Percentage of cassava in the ration			
Raw materials	0%	10%	20%	30%
Ingredients				
Maize	60	50	40	32
Cassava flour	0	10	20	30
Rice flour	12	14	13	10
Cottonseed cake	7	8	7	6
Soybean cake	6	7	7	7
Fish flour	9	9	11	13
Wheat middling	4	0	0	0
Premix (i.e. minerals, etc)	2	2	2	2
Nutrients				
Energy (kcal ME/kg)	2992	2995	2989	2989
Protein (%)	19.08	19.10	18.96	18.90
Lysine (%)	1.02	1.03	1.07	1.12
Methionine (%)	0.40	0.40	0.42	0.42
Methionine + cystine (%)	0.71	0.70	0.70	0.71
Calcium (%)	1.00	1.00	1.12	1.26
Available phosphorus (%)	0.56	0.57	0.61	0.66
Cellulose (%)	3.80	3.70	3.60	3.40

Source: Tiémoko (1992)

Table 7 shows the results of the feeding trials in Ivory Coast based on the experimental rations indicated in Table 6. The experimental phase ranged from the 29^{th} to the 49^{th} day of broilers of improved stock. The incorporation of cassava flour in poultry diet at rates ranging from 10% to 30% did not affect the final weight or the gain in weight ($P > 0.05$) of the chickens (Tiemoko, 1992). If the rate exceeded 10%, however, the feed consumption index increased, resulting in a lower nutritional efficiency of the diet.

At the same time, it is important to bear in mind that these figures were obtained under experimental conditions. Given uncertainties related to the quality of dried cassava and toxicity issues, a lower level of inclusion in poultry feed rations should be envisaged in Uganda for the time being (i.e. 10%). This is also in light of research undertaken in Ghana during the 1990s, recommending an inclusion level of 10% in poultry rations. Also, palm oil was included in the diets, in order to avoid a reduction in feed uptake by the birds due to the powdery nature of feeds containing cassava flour.

Table 7. Effect of cassava on the growth performance of broilers.

	Percentage of cassava in ration 0%	10%	20%	30%	Commercial Check
Live weight at 49% days old (g)	1657	1617	1610	1623	1656
Weight gain (g) (29 – 49 days)	977	936	930	943	976
Food consumption (g) (29 – 49 days)	2471	2361	2615	2789	2618
Consumption index (29 – 49 days)	2.53	2.52	2.81	2.96	2.68

Source: Tiémoko (1992)

Studies have shown that digestibility and milk production were not affected by 100% substitution of maize meal in dairy rations (Sanda and Methu, quoted in Lekule, 2000). Zimbabwean research showed that it is possible to obtain satisfactory results in steer fattening with a 44% content of cassava meal (Kleih, 1994). This corresponds to a fattening ration where two thirds of maize is substituted by cassava while maintaining the protein content at 11 – 12% through an increased proportion of protein concentrate.

As for the pig industry, European manufacturers successfully trial-fed cassava at the 60% level (Phillips, 1974). Lekule, (1992) conducted research in Tanzania to compare relatively cheap cassava based pig rations to diets based on *hominy* feed (milling by-products) and bloodmeal. Although the *hominy* based feed achieved the best result, it was shown that 40 kg pigs also performed well on 63% cassava root meal mixed with 30% cottonseed cake, 2.5% fishmeal, and 2.5% bloodmeal. Performance was lower when the cassava / cottonseed mix was only supplemented by either fishmeal or amino acids.

Research carried out in the 1980s in Zimbabwe by Dr Mandisodza of the Zimbabwean Pig Industry Board showed the best results when cassava meal was included at 20% and 40% levels in pig diets (Kleih, 1994). The results were comparable to that of a low fibre maize meal diet. Performance was lower when the cassava content was 60%.

Based on a 10% inclusion of cassava in animal feed rations, the annual potential demand for dry cassava chips in Uganda is of the order of 7,500 tonnes. This corresponds to 18,750 tonnes of fresh roots, assuming a conversion ratio of 2.5 to 1.

Table 8. Pros and cons of using cassava in animal feed rations in Uganda

Pros	**Cons**
Higher energy than bran	Need of extra nutrients (e.g. proteins)
"Usually" cheap source of energy	Toxicity issue (i.e. cyanide)
Relatively low quality requirements	Lack of information on utilisation
High fibre content advantageous in ruminant diets	Dust can reduce feed intake in poultry if not pelleted
Little additional investment required for processing equipment	No regular surplus production
High production potential	Considered food security crop for humans
Flexible timing of harvesting possible (i.e. mature roots can be left in the ground)	

When asked about the price they would be willing to pay for dried cassava chips, feed millers suggested either one third of the maize price, which was Shs220 - 300 per kg, or Shs50 – 70 per kg of dried chips. Given the feed value of cassava, this appears low. Aside from the price of alternative grains, the price of cassava also depends on the price of the protein balancer required (e.g. cottonseed cake, or fish meal). The research indicated above from Ivory Coast suggests that the price of dried cassava must not exceed 75% of that of maize used as a reference if it is to compete successfully with maize (Tiemoko, 1992). This figure is indicative only, in that the availability of other raw materials such as millets and sorghum or brans needs to be taken into account as well.

It is suggested that feed millers should consider a price for dried cassava chips which is of the order of 50 – 70% of the maize price, so that farmers are provided with a sufficient incentive to produce roots for animal feed. Prices for cassava flour observed during the course of the survey (i.e. second half of 2000), which were around Shs300 – 350/kg in Jinja, indicate that cassava was too expensive to be included in animal feed. This was influenced by drought conditions in Uganda in 1999/2000, resulting in increased demand for cassava and high food prices in general.

Prospects

According to Tiemoko (1992), there is no doubt that cassava can replace cereals as an energy source for animal feeding in Africa. However, cassava is still a subsistence crop in Africa rather than a competitive commercial commodity because of the limited size of farms, low yields, and the lack of facilities for efficient processing and distribution.

The current situation in Uganda is similar to Tiemoko's observation. In the near future a 10% inclusion of dried cassava can be envisaged provided its price is competative when compared to other sources of carbohydrate. The following requirements have been identified in order to initiate a sustainable cassava production for commercial utilisation in animal feed:

- Dissemination of information amongst industrial end-users on cassava utilisation (e.g. literature, workshops, trials);

- Stimulation of sustainable surplus production of roots

- Quality assurance with regard to chipping, drying and storage of roots at farm level

- Improved link between cassava producers and industrial end-users. Options to be considered in this context include, well designed outgrower schemes (i.e. based on realistic expectations on both sides), strengthening of farmer associations, and strengthening of private sector enterprises (i.e. processors and traders).potentially playing an intermediary role between industry and cassava producers.

The feed industry expressed a strong interest in further collaboration involving research and the dissemination of information relevant to the inclusion of cassava in animal feed rations.

PLYWOOD

The process of plywood production involves gluing together a number of thin sheets of timber (laminates) to form a much thicker and stronger board or panel. The laminates are stuck together using synthetic resin based glues (urea or phenol formaldehyde), that require a combination of catalyst (hardener), high temperature and pressure to form a bond between the laminates. Synthetic resin glues are expensive typically costing around $2,000/tonne. To reduce costs, synthetic glues are normally mixed with either maize starch or food grade wheat flour. These compounds are known as extenders because they enable the factory to produce more plywood panels per bag of glue, thus reducing unit costs of production. Typically 50kg of synthetic glue will make 55-60 1/8" plywood panels, with an extender this increases to 80-85 panels of 1/8" plywood. For each 50 kg batch either 10kg of maize starch or 25kg of wheat flour is normally required (Day *et al* 1996).

In a conventional plywood process, synthetic adhesive contributes approximately US$1.85-US$2.0 per sheet. Conventional glue extenders (maize starch & wheat flour) can reduce this cost to US$1.38-US$1.54 (inclusive of cost of extender) depending on the cost and amount of extender used. In many countries high quality cassava flour can be produced at a significantly lower cost than wheat flour, thus offering potential to make further savings on unit cost of production.

Many plywood factories in tropical regions rely on expensive imported wheat flour as a means of reducing the cost of production, and thus are very keen to achieve a 100% replacement of wheat flour with cheaper locally produced cassava flour. This is not possible in practice, as cassava flour is not as efficient as wheat flour at forming a strong bonding complex with the resin. The percentage of cassava flour that can be used without unacceptable reductions in bond strength is determined by the quality of flour, and the demands of the end user of the plywood.

Plywood manufacturers are not concerned with cyanide content, microbiology, colour, taste or odour of the flour, but would not expect a flour to shown signs of mould. In practice the flour must be prepared from peeled roots, dried to 10-12% moisture content and milled and screened through 0.25mm steel or brass mesh. Fibre content should be kept low as this interferes with adhesive bonding.

In Ghana substitution levels of 20-40% cassava flour were considered acceptable by the plywood industry. At 50% substitution the quality of the plywood panels did not meet the customers specifications, and at 60% the panels could be delaminated by inserting a fingernail into the glueline between the laminates.

Production of plywood in Uganda

The plywood sector in Uganda consists of only one company (Nile Plywoods) who are based in Jinja. The company controls 65% of the domestic market for plywood, with 35% of the market going to imported plywood from Kenya. The company uses cassava flour as an extender for imported urea formaldehyde glue (imported from Ireland, India and Saudi Arabia) on a 1:1 ratio of flour to adhesive. The company purchases 72 tonnes of cassava flour per annum (216 tonnes of fresh roots), via a local trader in Jinja. The cost of flour is normally $184 per tonne, but can increase to as much as $237 per tonne during times of short supply (drought and during the rainy season).

The company has focussed on a single supplier, and has developed strong linkages with the trader. If the trader indicates that supplies could become unreliable the company purchases extra flour to build up stockpiles. The company has experienced no difficulties in obtaining reliable supplies of flour of the desired quality.

The company indicated that potential exists for increased demand for cassava flour, but pointed out that current demand for plywood is limited, and difficulties of obtaining timber supplies remain serious constraints to development of the plywood sector in Uganda. At the current time there appears to be little potential for increased demand for cassava flour from the plywood sector in Uganda.

PAPERBOARD FOR CARDBOARD BOXES

The process of paperboard production involves gluing together several sheets of heavy paper (kraft paper) to form a much thicker and stronger board. The inner most sheet (sandwiched between the flat outer or facing sheets) is formed into a series of ridges known as corrugations, hence the name corrugated board or corrugated cardboard. The individual sheets are stuck together using starch based adhesives (SBA’s). The adhesive is applied as a cold suspension to the sheets of paper, which then pass through heated rollers that apply pressure, and heat (~165°C) to form a bond between the sheets and drive off excess water from the adhesive.

Bauer[1] type starch based adhesives (SBA) consist mainly of starch or flour blended with certain chemicals. The essential ingredients for a maize starch SBA are starch, gelatinisation modifier (sodium hydroxide), viscosity enhancer/stabiliser (borax) and preservative (sodium formaldehyde). A basic formulation for 1 tonne of maize starch SBA in dry form would be as follows:

(i).	Maize starch (98.4%)	=	984kg
(ii).	Sodium hydroxide (1%)[2]	=	10kg
(iii).	Borax (0.1%)[3]	=	5kg
(iv).	Sodium formaldehyde (0.1%)	=	1kg

[1] - Invented by Bauer in 1935.
[2] - Also known as caustic soda and used in the range of 1-5% depending on pasting temperature required.
[3] – Range of 0.05-18% depending on operating speed of machinery, and type of paperboard required.

In addition to the basic ingredients fillers such as clay or coconut shell are sometimes added, and in some cases plasticisers, lubricants, bleaching agents and antifoams may be included. All of these will greatly increase the cost of the product and should only be used if essential to meet the users requirements.

Historically, the choice of starch for adhesive production was determined by availability of raw material in the country of manufacture. Potato starch was favoured in Europe, corn starch in North America and Australasia and cassava in Asia and Latin America. Cereal starches account for the majority of the worlds adhesive production are unsuitable as ingredients for adhesive manufacture in their native state due to poor rheological properties. To overcome these problems cereal starches are chemically modified by oxidation or limited hydrolysis with caustic soda. Cassava starch has been found to be superior to other starches for adhesive manufacture because it can be used in its native form, is cheaper to manufacture, has good flow characteristics, forms stable pastes with neutral pH and is miscible with synthetic resins (Dux 1967).

The key difference between maize starch and cassava starch/flour is the pasting temperature. Native maize starch has a pasting temperature of ~80°C which is too high for paperboard manufacture. The pasting temperature of maize starch is bought down to ~65°C using caustic soda. Native cassava starch/flour has the advantage over maize in having a pasting temperature of 62-68°C thus eliminating the need to use caustic soda in the adhesive formulation.

In a series of industrial trials in Ghana (Graffham *pers comm*), an SBA was prepared from high quality cassava flour (997.5kg) mixed with 0.05% soluble borax (2.5kg). Caustic soda and preservative were not used as these were found to be unecessary under Ghanaian conditions. The cassava flour based adhesive was used in place of a commercial maize starch SBA (Roquette 120S), and gave comparable results to the commercial adhesive under factory conditions. The operating speed of the factory was 36 metres per minute. In more modern factories operating at higher speeds (70-150 metres per minute) the percentage of borax would have to increased to approximately 0.1% (5kg per tonne of SBA) to take account of the reduced retention time on the rollers.

Table 9. Specification of cassava flour for use in SBA's/plywood extenders and textile sizing.

Parameter	**Starch based paper board adhesive**
Root maturity	10-12 months
Processing requirements	Peeled roots, chipped (mini chips) or grated and dried within 1 day of harvest.
Moisture (after drying)	10-12%
Milling quality / screening	Finely milled and screened to 0.25mm.
Impurities	Free of insoluble impurities
Pasting temperature	63-68°C

Production of paperboard in Uganda

The paperboard industry in Uganda consists of four companies. Two of these (Makks and Paper Products) are located in the capital, Kampala which constitutes the major market. Mulbox is located in Jinja formerly Uganda's industrial town while Riyaaska is in the eastern town of Mbale. A summary of the market for paperboard in Uganda is given in the table 10.

Table 10. Paperboard production in Uganda and consumption of starch based adhesives (SBA's) in November 2000.

Firm	**Output tonnes per/yr**	**Market share (%)**	**Quantity of SBA tonnes/yr**
Paper Products Uganda Ltd[1].	1200	35	0
Makks Packaging Industries Ltd[2].	840	25	120
Mulbox Ltd[3].	780	23	67
Riyaaska International Ltd[4].	600	17	18
Total	**3,420**	**100**	**223**

[1] - Imports paperboard from Kenya, but intends to establish a corrugating line in a years time.
[2] - Imports native maize starch and prepares SBA at factory
[3] – Imports 13 tonnes of SBA and mixes with 54 tonnes of locally purchased cassava flour (162 tonnes of fresh cassava).
[4] – Imports SBA

At the present time (November 2000) cassava flour accounts for 24% of the demand for starch based adhesives by the paperboard industry. However, Mulbox intend to start making their own cassava flour-based SBA in 2001. The company also plans to expand production. If these plans are completed successfully the companies requirement for cassava flour will increase to 96 tonnes per annum (288 tonnes of fresh cassava).

Cassava flour is purchased for between $153 to $237 per tonne depending on availability. Even allowing for the cost of soluble borax used in preparation of a cassava flour-based SBA this remains a favourable price when compared with imported native maize starch ($470-$500 per tonne delivered to factory gate) purchased from South Africa or Kenya, or imported Kenyan maize starch-based SBA at $800 per tonne (delivered to factory gate).

One company had considerable success using cassava flour as a base for its SBA in the past (1995), but decided to discontinue usage when the supplier proved to be untrustworthy.

There appears to be limited potential for increased demand for cassava flour in the paperboard sector, but demand for paperboard appears relatively buoyant and the sector should prove a reliable if rather small industrial market for cassava flour in the future.

TEXTILES

Starch is an important raw material for the textile industry, finding applications in sizing, finishing and printing of textiles. Small amounts of native starch are used as thickeners in printing inks, and modified starches (oxidised starches) are used to increase the weight and stiffness of finished fabrics, and for application of glossy finishes. However, the main application for textile grade native starch is in sizing of the yarn for weaving. In the weaving process a solution of starch paste is applied to the yarn to improve the strength and flexibility of the yarn, and thus prevent breakage of individual threads on the looms. The amount of starch required will depend on the viscosity of the starch and weight of the yarn, but is typically in the range from 5-15% of the weight of the yarn.

Native starch for textile sizing must be white in colour, free from contaminates and off odours, moisture should be between 10-12%, pH 4.5 - 5.5, ash content 0.2% (max) and the granule size should be such that 99% of starch granules pass through a 100 mesh screen. Viscosity and solids content must be uniform, and consistent between batches of starch. Easy of pasting and translucency of the hot paste are desirable criteria.

Maize starch has the advantage over cassava in having a more stable hot paste viscosity. On the other hand cassava starch pastes at a lower temperature (thus reducing energy inputs), and unlike maize it will completely gelatinise on boiling. Cassava starch size gives a more translucent finish, and greater yarn flexibility on the loom, as well as having better keeping qualities.

The final choice of starch for sizing depends on cost, availability and quality requirements. In the USA and Europe maize starch is usually used because of its cheapness and ready availability. In India and South East Asia, cassava starch is most often used, although India also uses maize starch in areas where maize starch is more readily available than cassava starch. In Ghana and Nigeria several textile mills are using locally produced cassava flour for textile sizing. Cassava flour is normally used in production of lower quality fabrics such as those used for making uniforms, and overalls, and is selected on the basis of cheapness and ready availability.

Production of textiles in Uganda

The textile manufacturing sector in Uganda is in a serious state of decline. Although three factories are listed in the UMA directory, only one factory is still operational (African Textile Mill located in Mbale). ATM purchases cassava flour from local traders in Pallisa and Mbale at a price of $153-$158 per tonne. The company currently uses 36 tonnes of cassava flour (equivalent to 108 tonnes of fresh roots) per annum, and does not envisage any increase in demand for flour in the near future. Cassava flour for textile use must be unfermented, free of foreign matter, odourless and a white colour is preferred.

Prospects

Cassava flour is already used by the industry, who have not experienced any problems with quality, quantity or timeliness of supply. Given the state of the textile industry in Uganda there appears to be little prospect of increased demand for cassava flour in the future.

FOOD INDUSTRY (BAKERY & PROCESSED FOODS)

The category of food processing comprised of; bakeries, biscuit manufacturers, food processors and millers. The bakeries visited included; Hot Loaf Bakery Ltd., Daily Bread/ King Loaf, FADCA and TipTop while the biscuit manufacturers included; Riham Industries Ltd. and Britania Products (U) Ltd. The millers visited were; Maganjo Grain Millers, Kengrow Industries Ltd. and Uganda Grain Milling Co. Ltd. A Cassava Crisp manufacturer named Shakti Bakers Limited was also visited during this survey. Britania Foods (U) Limited was the only processed food company visited.

Current Usage

At present, the factories visited were found to be using wheat flour in the manufacture of bread (69% of weight of loaf) and biscuits (20-25% of the weight of the biscuit). Some of the bakeries and biscuit manufacturers had undertaken trials with cassava flour but had encountered problems with flour quality and lack of information on the effect of using cassava flour in bakery products.

Although no bakeries are currently using cassava flour, several industries expressed interest in being involved in trials to assess the potential of using cassava flour in the future.

Quantities

The total demand for wheat flour among bakeries and biscuit manufacturers was estimated at 90,000 tonnes per annum, of which 2,000 tonnes is used by biscuit manufacturers. Using a substitution rate for cassava flour of 10% in the various recipes, the estimated annual requirement for cassava flour would be 9,000 tonnes which is equivalent to approximately 27,000 tonnes of fresh cassava roots. However, in practice cassava flour is more likely to be accepted in biscuits than in bread in the near future, thus reducing the requirement for cassava flour to 200 tonnes or 600 tonnes of fresh roots per annum.

One of the grain milling companies visited, was found to be producing a composite flour containing cassava and millet. The production of this product was 12 tonnes per annum.

The market for food grade native maize starch was found to be very small. Britania Foods which accounts for 80% of the market for tomato and chilli sauces and ketchup in Uganda, uses 36 tonnes of food grade native maize starch per annum. The total demand for food grade starch in Uganda can be estimated at 50 tonnes per annum.

Prices

Wheat flour purchased from the five main millers of grain in Uganda costs between $421 and $442 per tonne. The grain used by these millers is imported from Australia, USA through a project PL-480, Europe and Kenya.
Food grade native maize starch imported from Kenya cost $545 per tonne delivered to the users factory. A similar product imported from Dubai cost $631 per tonne delivered to the factory.

Specification for high grade cassava flour

Although no formal specification exists for unfermented high quality cassava flour in Uganda, standards developed by biscuit makers in Ghana and Nigeria (Table 11), can be taken as a fair indication of the requirements of the bakery industry in Uganda.

Table 11. Specification for cassava flour defined by biscuit manufacturers in Ghana and Nigeria.

Parameter	Requirement
Moisture	Dry
PH	Not sour
Colour	White
Odour	None
Taste	Bland
Sand and other extraneous matter	Absent
Cyanide (maximum)	Absent or low level
Dimensions	Finely milled
Shelf life	1-2 months ambient storage.

Graffham, *pers comm* (2000)

Prospects for the use of cassava flour in baking

- The cost for production of high quality cassava flour is likely to be about 50% of the cost of wheat flour, depending on raw material and processing costs. Given a substitution of 10% in bakery products, high quality cassava flour has the potential to reduce the cost of flour in biscuits and bread by 5%.

- There is a long-term possibility of using relatively large quantities of high quality cassava flour in the biscuit and bakery industry (9,000 tonnes per annum or 27,000 tonnes fresh roots per annum). However, in the short-term (5 years) uptake is likely to be restricted to the biscuit industry with potential demand for

200 tonnes of cassava flour per annum (600 tonnes of fresh roots per annum).

- The major economic determinant influencing this opportunity is the rising cost of wheat flour set against the potential to produce cassava flour at a lower price. If the cost of wheat flour continues to rise, and the Ugandan Shilling continues to lose value against the US Dollar cassava flour will become an increasingly attractive option for the bakery industry.

Constraints to the use of Cassava Flour in Baking

- Cassava flour lacks gluten, which is a vital protein responsible for expansion volume, colour and flavour of bakery products.

- Products containing cassava flour have a shorter shelf-life when compared to products made from 100% wheat flour. Bread prepared by a rural baker in Ghana containing 30% cassava flour had a shelf-life of 3-4 days under village conditions. Conventional wheat flour bread prepared by the same baker had a shelf-life of 7 days.

- High quality standards are required for the production of cassava flour for bakery use in order to ensure consumer acceptability of the finished product.

- Inclusion of cassava flour in baking is very susceptible to consumer sensitivity, as urban consumers often do not like the changes in product quality (reduced loaf volume, heavier texture, reduction in golden colour) that are associated with incorporation of cassava flour in bread.

Requirements

Given that the rate of urbanisation in Uganda has been estimated between 10 and 15% it would be reasonable to suggest that the potential market for cassava flour in bakery products could be between 10,000 - 20,000 tonnes per annum by 2010.

The immediate requirements for development of this market opportunity are as follows:

- There is also a need to disseminate information about the potential for high quality cassava flour in bakery products through workshops and seminars to the various stake-holders (especially private sector) in order to increase their awareness.

- An integrated approach should be adopted, whereby research organisations form close links with private sector partners to examine issues of economic and technical feasibility of exploiting the opportunity, preparation of business plans, and development of closer links between the urban end user of the product and rural producer of fresh or dried cassava.

- There is need to review wheat flour import practices in order encourage the growth of cassava flour industry.

- There is need to improve cassava processing technology in order to stimulate increased surplus production and also facilitate the post-harvest handling of the commodity.

- There is need to sensitise farmers about the importance of producing cassava flour of consistently high quality in order to meet the requirements of the end users. Farmers need to be trained and equipped with better techniques for producing a high quality product.

PHARMACEUTICALS

Native starch is widely used in the making of tablets, capsules and powder formulations. In tablets the starch serves a dual role, acting as both a coating and dusting agent and also as a binder for the pharmaceutically active components of the tablet. In tablets and capsules the starch serves a further purpose, as it will absorb moisture and swell after swallowing resulting in disintegration of the tablet and dispersal of the active ingredient. In powder formulations starch is used mainly as a binder and filler.

Pharmaceutical industry in Uganda

Uganda currently has four manufacturers of pharmaceutical products (Medipharm Industries Ltd., Uganda Pharmaceuticals Ltd., Rene industries Ltd. and Kampala Pharmaceutical Industries Ltd) all of which were visited during this survey.

Current Usage, Quantities and Prices

At present, pharmaceutical grade maize starch is used by all of the Ugandan pharmaceutical industries. The total requirement for pharmaceutical grade starch in Uganda is currently 198 tonnes per annum. In addition one company uses 160 tonnes of powdered glucose and glucose syrup per annum in the manufacture of Oral Rehydration Salts and syrups.

Prices

Prices range between $800 - $1,100 per tonne, depending on the origin of the product. Starch from German companies (Cerestar, Helmuth Carroux and National Starch), costs between $900-$1,100 per tonne, delivered at factory gate. Powdered glucose from Germany costs $850 per tonne (f.o.b Hamburg). Liquid glucose imported from Kenya costs $820 per tonne cif Kampala. Other countries which supply maize starch to the pharmaceutical industry in Uganda include; Israel (Galam Ltd.), Kenya (CPC, Tapioca Ltd.) and the Netherlands.

Prospects

The market for pharmaceutical starch in Uganda is still small with pharmaceutical manufacturers facing stiff competition from importers of ready made drugs (mainly from India). To manufacture pharmaceutical grade starch would require a high level of investment in a starch factory equipped for artificial drying (flash drying) of the product. Since the market size is only 198 tonnes per annum it is clear that there would be no possibility of making a recovery on the investment via this market, and hence there is no potential for manufacture of pharmaceutical grade starch in Uganda in the foreseeable future.

LAUNDRY STARCH

Native starch is commonly used in the washing of bed sheets and tablecloths to improve the life of the fabric and retain stiffness and finish of the material. Modern laundries often use soluble starch packaged with a suitable propellant in aerosol cans for starching garments during steam ironing. Uganda has approximately 10 laundries (commercial, hotel and hospital) most of which are situated in Kampala. A visit was made to the largest of the commercial laundries. This company uses 75kg of imported native maize starch per annum for laundering of clothes. In addition the company uses approximately 1,400 aerosol cans (628g capacity) of soluble starch per annum. The canned product is imported from Dubai (United Arab Emirates) at a cost of 6,000 Ugandan Shillings ($3.16) per can. Given a similar level of consumption amongst the other laundries the total market for laundry starch in Uganda can be estimated to be 1 tonne per annum, 75% of this demand could be met with native starch.

Cassava starch has a lower pasting temperature than maize starch, and will give a better level of gelatinisation during the boil wash, giving cassava a slight advantage over maize for this application. However, the market for laundry starch in Uganda is very small, with little potential for significant growth. Given the small market size there is no potential for local production of laundry starch in Uganda.

STARCH AS FILLER IN SOAP AND DETERGENT POWDERS

Uganda has eleven manufacturers of soap and detergent powders. Native starch is often used as a filler in soap manufacture (4-15%), and is normally blended with the soap granules prior to milling. Starch for this purpose should have a high gloss, maximum whiteness and be free of chlorine and acid. Any type of native starch can be used, and cassava starch has no comparative advantage over other materials.

Visits were made to two soap manufacturers in Uganda, neither company used starch, although one company was aware that starch can be used in soap manufacture. If starch was used in soap manufacture, the likely demand for starch would be approximately 100 tonnes per annum . However, the key criterion for selecting fillers is cost, and manufacturers always opt for the cheapest source of filler. The companies interviewed use sodium silicate and china clay as fillers. These compounds cost 460 ($0.24) Ugandan Shillings and 220 Ugandan Shillings ($0.12) per kg respectively. Native maize starch imported from Kenya costs approximately 950 Ugandan Shillings ($0.5) per kg making starch uneconomic as a filler in Uganda.

PRODUCTION AND UTILISATION OF ALCOHOL IN UGANDA

At the time of writing there is only one industrial manufacturer of alcohol in Uganda. The distillery was established to make use of the molasses produced as a by-product of sugarcane refining which is the main business activity of the company. The sugar refinery currently produces approximately 9,000 tonnes of molasses per annum. Approximately 50% of the molasses is fermented and distilled to produce 1,000,000 litres of rectified spirit (96% ethyl alcohol), giving a recovery rate of 220 litres of rectified spirit (RS) per tonne of molasses. The majority of production of RS is sold to the two major distilleries in Uganda for use in production of *waragi* (potable liquor). A small amount of RS is mixed with methanol and sold to hospitals for use as a cleaning agent. The company was not aware of any demand for RS for use as an industrial chemical in Uganda.

RS is usually sold for between 900-1000 Ugandan Shillings per litre ($0.47-0.53) exclusive of 45% excise duty and 17% VAT. Sugar cane molasses normally sells for 73 Ugandan Shillings per kg ($0.04). However, the prolonged drought in Kenya and Eastern Uganda pushed prices up to 1500 Ugandan Shillings per litre ($0.79) for RS (ex duty & VAT) and 152 Ugandan Shillings per kg ($0.08) for molasses in November 2000.

The company has the capacity and raw material available to produce 3,000,000 litres of RS per annum if demand for RS should increase in the future. The major constraint to increased output is the limited size and potential of the market in Uganda, which lacks capacity for production of industrial chemicals, plastics and primary production of pharmaceutical chemicals.

Potential for cassava as a feedstock for production of industrial alcohol
In theory almost any source of fermentable sugar could be used to prepare industrial alcohol. In practice, economic and technical restrictions limit the range of substrates to mollases and sugarcane in developed areas of the world. Cassava has long been recognised as a potential substrate for alcohol production (Jackman, 1987) in tropical areas. In Nigeria high quality cassava flour is being used as a substrate for ethanol production by several distilleries. However, technical problems have been encountered when using cassava, and the high cost of imported enzymes for saccharification remains a major constraint. Similar problems have been reported by industrial distillers in Ghana when using cassava. Although cassava flour can be used for alcohol production, yields are well below expectations, with high levels of waste (sludge and unhydrolysed starch), blockages to heat exchangers and increased hydrolysis times. The major problem appears to be that the industries are attempting to use equipment and procedures that were not designed for cassava, even though it is well known that the design of processing systems for industrial alcohol is determined by the nature of the raw material used (Jackman, 1987).

Conversion of cassava flour/starch to fermentable sugar greatly increases production costs, and thus cassava will only be considered as a substrate in industrialised countries where readily fermentable materials such as molasses are not available. In Nigeria and Ghana interest in cassava was triggered by the collapse of the local sugarcane industry and high cost of imported alcohol.

As Uganda has ample supplies of molasses, and does not import much alcohol, there would appear to be no potential for utilisation of cassava in alcohol production in the foreseeable future.

DEVELOPING INDUSTRIAL OPPORTUNITIES FOR CASSAVA

Industrial markets for agricultural products can appear highly attractive to potential investors, as they appear to offer the promise of steady demand, stable prices, and prompt payments, especially when compared to traditional markets for the commodity. However, experience in Ghana has shown that the relationship between the supplier of the raw material and the end-user may breakdown if certain factors are not taken into account. Discussions with representatives of Ghanaian industries have highlighted the following as the most important points to take into consideration (Graffham, 2000):

- **Manufacture of products to meet the required quality specifications -** Before starting production of cassava-based product, it very important to determine the customer's requirements on quality, and for producer and user to agree a standard for quality of the product.

- **Reliability in maintaining quality** - When a quality specification has been agreed, it must be maintained at all times. The use of adulterants and short cuts to reduce costs and process times must be avoided.

- **Reliability of supply (quantity) -** Processors must never promise more than they can produce by the agreed delivery date, as the end user will be planning his production on the basis of having the necessary quantities of raw materials.

- **Timeliness of delivery -** Realistic delivery dates are a must for commercial success.

- **Price competitiveness -** Industrial users want a local product that is cheaper than the imported alternative. However, reduction in price must not be achieved at the expense of quality.

It is vitally important for anyone wishing to market cassava-based products to industry to keep these criteria in mind at all times. Many industries in Ghana expressed a willingness to be tolerant of the manufacturers difficulties, as long as they were kept fully informed, but were not happy with past experiences of producers of cassava-based products who were found to be unreliable on quality quantity and timeliness of delivery.

The lessons learned from Ghana, apply to Uganda as well. During the industrial survey in Uganda several industries reported having had bad experiences with suppliers of locally made cassava flour. These problems included adulteration, financial fraud, and failure to maintain regularity of supply.

DEVELOPMENT OF LINKAGES BETWEEN PRIMARY PRODUCERS (FARMERS) AND INDUSTRIAL USERS OF CASSAVA-BASED PRODUCTS

During the course of the survey, it became apparent that the link between potential industrial users and farming communities is missing. As a consequence, building of this link is key to the success of a future cassava economy not only producing for human consumption but also for the industrial sector. The improvement of market linkages needs to be incorporated into the overall set of recommendations, which include:

- Dissemination of information to potential industrial end-users of cassava based raw materials. This includes distribution of literature, and organisation of workshops.

- Supply of adequate samples of raw material to industries interested in trials (e.g. poultry feeding industry, bakeries, and biscuit manufacturers).

- Identification of options establishing a link between farming communities and industrial end-users.

- Sustainable surplus production of good quality raw material, including processing of roots into dried chips and flour where required.

There are two main options to be considered for the establishment of the link between farmers and the industrial sector:

(a) Outgrower schemes, whereby farmers and end-users are in direct contact, or

(b) Private intermediaries (i.e. traders and processors) providing the missing link.

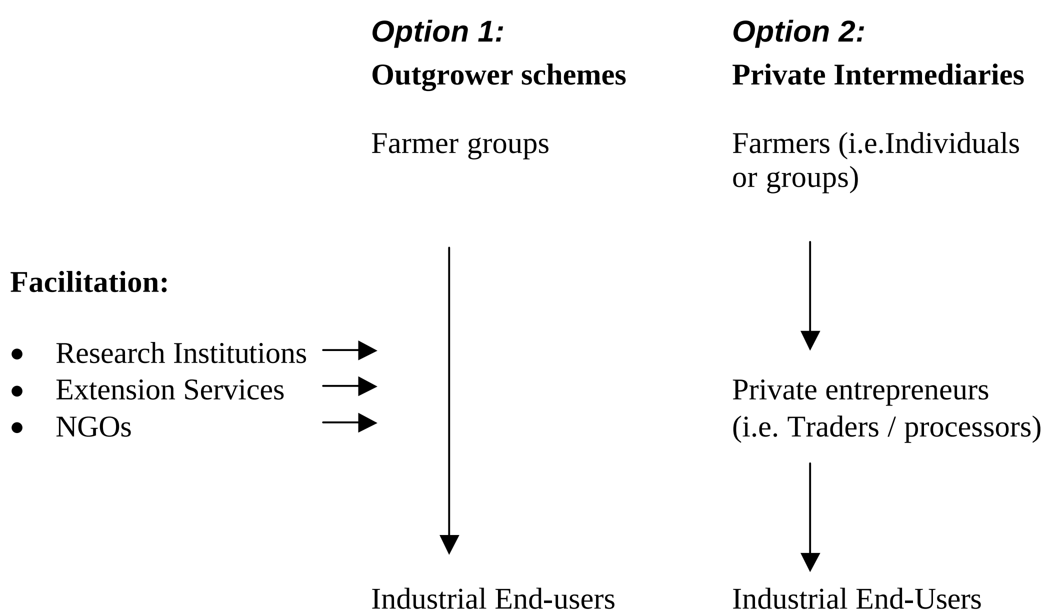
As for (a), two industrial companies indicated that they had attempted <u>outgrower schemes</u> in the past, which in the end proved unsuccessful (e.g. production of sunflower for animal feed). The reasons given for the failure of these schemes include occurrence of difficult production conditions (i.e. drought), low yields, higher prices offered elsewhere by other buyers, and default by farmers. At the same time, it also transpired that these initiatives, which were started by feed millers, were most likely based on unrealistic expectations. The prices offered by the millers were not attractive enough for farmers to sell their produce to them, in particular when there was a shortage elsewhere. Insufficient extension services are likely to be another constraint faced by the schemes.

For future outgrower schemes (i.e. contract farming), it seems important that these will be based on realistic expectations on both sides, i.e. farmers and end-users. This calls for agreed price formulae reflecting prevailing market prices, farmers' need of sufficient margins, and end-users' demand for relatively inexpensive raw materials. The precondition of sufficient surplus production requires efficient extension services, including, if necessary, the provision of adequate planting material. Feed millers indicated the possibility of part-using their sales agents based at District level as extension link. Given the size of most farms in cassava producing communities in Uganda, the formation of farmer groups seems necessary in order to reduce high transaction costs in input supply and output marketing. At the same time, it is important that farmer co-operation will be based on realistic assumptions, and that mistakes made in the past can be avoided. Gordon (2000) and Coulter *et al* (1999) examined approaches to outgrower schemes and farmer co-operation in various sub-Saharan countries.

The second option consists of private intermediaries providing the missing link between farming communities and industrial end-users. In particular, this option should be envisaged where outgrower schemes are likely to encounter difficulties. Local traders currently supply the plywood and cardboard manufacturing industries with comparatively modest quantities of cassava flour. If industries, such as the livestock feed sector, should require larger quantities of cassava, and do not wish to engage in outgrower schemes, then it seems appropriate for private entrepreneurs to provide the missing link. For example, traders who are already involved in dealing with dried cassava, could be encouraged to invest in chipping and drying units catering for the needs of small farmer groups. Traders could then either purchase fresh roots from producers and sell dried chips to industrial users, or charge farmers for their services.

As indicated rudimentarily in Figure 1, the implementation of both options (i.e. outgrower schemes, or private intermediaries) is likely to require the facilitation by research institutions, NGOs, and extension services. For example, research and extension services have to play a pro-active part in the introduction of appropriate cassava chipping and drying technologies. At the same time, industrial end-users have to commit themselves to strengthen market linkages in whatever form, and make related investments. Last but not least, the Government needs to provide an enabling economic environment, including a conducive regulatory and legal framework.

Figure 1. Options for improved market linkages between cassava producers and industrial end-users.



KEY CRITERIA FOR ENTREPENEURS WISHING TO FORM MARKET LINKAGES AND CARRY OUT SECONDARY PROCESSING

Some of the products require specialised secondary processing (e.g. adhesive formulation) that cannot be done in the village. There is clearly a need for entrepreneurs who can form the necessary linkages, provide financial support for rural processors and carry out secondary processing operations. The most important criteria for entrepreneurs who could fulfil the role of market linkage and secondary processor, include:

- Access to capital;
- Access to processing facilities and commercial transport;
- Relevant manufacturing experience;
- Proven business record (success over 10 years or more);
- Proven record on quality;
- Understanding of the market system and issues involved;
- Willingness to support farmers and primary processors for mutual gain.

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ANNEX 1. Detailed questionnaire suitable for use with paperboard industries

The detailed questionnaire developed for this survey is a 47 page document, containing 10 questions. However, the full document is not intended for use during individual interviews. Only two questions are used for each industrial visit. The first being question one which is common to all types of industry, and the second being selected from questions two to ten using the table on the front page of the questionnaire.

It is good practice to memorise the questions before visiting the industries, as the open use of a questionnaire may hinder the flow of information and even raise suspicions in some companies. Upon completion of a set of visits, information can be transferred from notebooks onto the blank questionnaires. This exercise will help to organise the information obtained, and highlight any gaps in information, requiring follow-up visits or phone calls.

The following is an example of a questionnaire for use in interviewing manufacturers of paperboard and cardboard boxes, and thus only contains the cover sheet and questions one and ten.

Electronic copies of the full questionnaire can be obtained from Dr Andrew Graffham at NRI (a.j.graffham@gre.ac.uk) or from Dr Shaun Ferris at IITA/FOODNET in Kampala, Uganda (foodnet@imul.com).

EXPANDED MARKETS FOR CASSAVA

INDUSTRIAL SURVEY

GENERAL
Question one covers general information and should be asked of all industries visited.

QUESTIONS RELATING TO SPECIFIC COMMODITIES/APPLICATIONS
Questions two to ten relate to specific commodities, table 1 gives guidance on which questions apply to which industries. Interviewers should assemble their question sheets in advance to ensure that only relevant questions are asked in each factory.

Table 1. Selection of commodity/application specific questions

Industry type	**Questions**	**P – Priority** **LP – Low Priority**
1. Livestock feed millers	1 and 2	P
2. Flour millers	1 and 3	P
3. Bakeries and biscuit manufacturers	1, 4 and 6	P
4. Manufacturers of sugar syrups and alcohol's (industrial & potable)	1 and 5	P
5. Manufacturers of confectionery and soft drinks (includes fruit juices)	1 and 6	LP
6. Manufacturers of pharmaceuticals	1, 6, 7 and 8	LP
7. Manufacturers of paints	1, 7 and 8	LP
8. Manufacturers of plastics	1 and 7	LP
9. Manufacturers of industrial chemicals (including dextrin's)	1, 5 and 7	LP
10. Manufacturers of textiles	1, 8 and 8a	P
11. Manufacturers of paper	1 and 8	P
12. Manufacturers of soaps & detergents	1 and 8	LP
13. Manufacturers of cosmetics	1 and 8	LP
14. Manufacturers of leather goods	1 and 8	LP
15. Laundries	1 and 8	LP
16. Manufacturers of dry cell batteries	1 and 8	LP
17. Manufacturers of processed foods	1 and 8	P
18. Manufacturers of plywood	1 and 9	P
19. Manufacturers of paperboard, packaging and envelopes	1 and 10	P

Many of the questions contain notes in italics that are intended to help the interviewer in guiding the discussion so as to gain maximum information.

An important general point: When asking about costs and prices (particularly for imported raw materials), make sure you get a clear statement of what the price means, for example $400 /tonne means nothing, is it FOB, CIF or receipt at factory gate, if you are quoted FOB or CIF then ask where (eg $400/tonne FOB Kampala). In every case you should try to get an estimate of the total price for delivery to the end user (all costs inclusive).

DATE:

Before asking questions make clear the purpose of the visit and give brief details of the project and its expected outcomes. You should provide brief details on the potential of cassava for the specific user, quoting examples from other countries or regions (Ghana, Nigeria, India, Thailand and Latin America (Brazil & Colombia).

QUESTION 1.
(always try to get a business card, as this might be useful later, do give copy of letters UMA and NARO letter)

1.1 General information

Company name:

Full postal address *(with details of physical location)*:

Phone *(with area code)*:

Fax:

Mobile:

Email:

Name of respondent(s): **Position:**

1.2 Type of business *(eg plywood factory, textile mill etc)*:

1.3 How long has your business been operating?

1.4 Product range? *(eg non water resistant paperboard, water resistant board etc)*:

1.4b Which of your products is most important to you? (in term of sales)

1.5 Do you experience fluctuations in demand for your products during the year?

1.5a Are there seasonal high or lows? *(obtain information on months)*

1.5b What is the cause of the seasonality? *(try to get a reason eg many bakeries experience peak demand associated with important religious festivals such as Ramadaan and Christmas):*

1.5c Do you experience unpredictable changes in demand for your products? *(If yes)* **What are the causes?**

1.6 What has been your annual output over recent years? *(tonnage or value, whichever is most appropriate, for a large factory tonnage is best, for a bakery an estimate of value would be more appropriate)*:

1.6b For the industry as whole, is demand for your main products static/increasing or decreasing: *(this question should help us to estimate market potential)*

1.7 What are your markets *(local / export / both, if both then what are the proportions for each market eg local 60% export 40%)*:

1.8 How does government economic policy affect your business? *(for instance interest rates, inflation, tax, import duties, privatisation, infrastructural investment)*

NAME OF COMPANY: **DATE:**

QUESTION 10 ADHESIVES FOR PAPERBOARD, PACKAGING AND ENVELOPE MANUFACTURE:

10.1 Do you use starch based adhesives or dextrin's in your products?

10.2 If yes, then what type(s) of starch based adhesives (SBA) or dextrin's do you use, source *(imported/local get details of supplier in each case),* amount of adhesive or dextrin required per tonne of product, cost of adhesive or dextrin, and month of purchase.

Type of adhesive/dextrin (NB repeat for each purchase made*)	Source	Amount used per kg of product (approximate)	Cost (note what price is quoted: CIF, FOB, Border, delivered to store)	Month and year purchased

* For instance, if the manufacturer buys a certain type of adhesive five times in a year, record each purchase separately

10.3 What has been your annual utilisation of SBA or dextrin in recent years, and is demand constant or due you have seasonal highs and lows in demand *(get details of these)*

10.4 If you are using more than one type of SBA or dextrin, what influences your choice *(eg price, quality, availability, product specification try to get details)*

10.5 In choosing an SBA / dextrin, what are your specifications

moisture % (max),

pH *(acidity)*,

Colour,

Odour,

total ash % (max),

crude fibre % (max),

Viscosity

Price (max per kg/tonne)

10.6 Do you face any problems in getting supplies of SBA or dextrin *(if yes get details, and ask how they overcome)*

10.7 Do you produce to a national standard, if yes do you send samples for analysis by UNBS *(is this voluntary or mandatory)*

Potential purchase of cassava based raw materials

(It may not always be possible to get answers to the following questions.   Try to engage the person interviewed in a discussion and probe if necessary. If you see it is impossible to get an answer don't insist).

10.8 If you don't use cassava based raw materials now, would you be prepared to do so in the future?

- If yes, why? (reasons, and conditions that have to be in place)

- If no, why not? (reasons, constraints)

If the answer was NO, go to Q10.14

10.9 Quantities of cassava based products potentially required in the future? Rates of substitution (e.g. cassava starch for maize starch) ?

10.10 If you were to use cassava based products, in what form would you want to buy them? What would be the minimum specifications required?

10.11 What prices would you be prepared to pay for cassava based products (range of price depending on quality). Is price for product "delivered at factory gate".
(If the person interviewed cannot give a clear price, try to obtain a price ratio, for example, dried cassava chips compared to maize, or cassava flour compared to wheat flour).

10.12 What potential suppliers of cassava based products (location and operators) can you envisage?

10.13 If you were to use cassava based products as raw materials, how would this influence your processing costs? (In many cases we are unlikely to get a clear answer to this, but it is important to obtain users' views).

Potential sales of cassava based end products

10.14 Which customers are more likely to purchase cassava based end products?

10.15 In what form do you think you could sell cassava based end products ?

10.16 What quantities of cassava based end products do you think you could sell per annum?

10.17 How many tonnes of cassava based end products do you think the different industries as a whole would be prepared to purchase per annum?

10.18 At what price do you think cassava based end products could be sold?

Follow-up

10.19 Would you be interested in receiving a copy of the findings and recommendations of this study?

10.20 Would you be interested in being involved in future activities *(eg industrial trials of cassava based products)?*

10.21 If necessary, would you mind if we came back to ask you more questions?

ANNEX 2. Checklist of key points applicable for interviewing any industry that uses starch-based raw materials

The checklist of key points was developed as a quick guide and reminder for project staff, of the key points to cover in any interview with industry. However, it was not intended to replace the detailed questionnaire (Annex 1), which should be carefully studied and committed to memory before starting survey activities.

Checklist of key points for the expanded markets for cassava industrial survey
All of the questions in the main checklist are important but the following are the most important questions and points to keep in mind when conducting an interview.

Question 1.
Always try to get a business card, as this will save time on question 1.

The following questions are most important:
1.1 Company details
1.2 Type of business *(eg plywood factory, textile mill etc)*:
1.4 Product range? *(eg non water resistant paperboard, water resistant board etc)*:

1.5-1.5c Questions relating to seasonality of demand

1.6 It is useful to get an idea of demand in the wider context of the national economy. Thus companies may have experienced higher demands in the past but be facing problems now due to the economic downturn in Uganda.

1.7 What are your markets *(local / export / both, if both then what are the proportions for each market eg local 60% export 40%)*:

1.8 deals with policy issues. It can be useful to probe for the respondents views on the effect of government policy on the success of business operations. For example market liberalisation may create conditions that favour imports, and make local manufacture of goods difficult.

Key points for questions 2-10.

- Which raw materials does the company use (flour, starch, sugar syrup etc)?
- For questions relating to starch users ask if starch is native or modified? Some users may use both.
- How much is used?
- Who supplies (local or imported)?
- How much does the starch-based raw material cost?
- Are there minimum and maximum prices for raw material (get details)?
- Quality specifications?

- Problems with quality of raw materials?

- Do you face any problems in getting supplies of raw materials *(if yes get details, and ask how they overcome)*?

- What influences choice of raw materials (cost, quality, quantity, availability & consumer preferences)?

Potential purchase of cassava based raw materials

Questions on future potential are important, additional points include:

- If you purchased cassava flour/starch/sugar syrup would you have a minimum quantity required to make use of cassava-based raw material worthwhile?

- What would be the maximum price that you would be willing to pay for cassava-based raw material?

- Can you envisage any problems with using cassava-based raw materials?

Examples of supply problems include – availability of cassava, reliability of supply (quantity, quality and timeliness of delivery)

Follow-up

In addition to the questions mentioned in the survey document, you should offer to give a draft copy of the notes of the interview to the industry for editing and mention that it is not the intention to disclose commercially confidential information. Industry edits should be taken into account before the final report is published.

ANNEX 3. List of companies who participated in the survey
Section to be provided by Kelly Wanda of Foodnet