Global Cassava Market Study

Business Opportunities for the Use of Cassava

Assembled by
dTp Studies Inc.

Funded by
IDRC and IFAD

July 1999

dTp Studies Inc.

25 Latenda Place
Guelph, Ontario
Canada N1G 2B8
Phone (519) 823-9241
Fax (519) 826-9359

Table of Contents

Table of Tables

Table of Figures

Preface

What may be called a rebirth in the interest in cassava can be dated to the International Fund for Agricultural Development's (IFAD) initiated meeting in May of 1996. As an outcome of this meeting a Task Force was formed to spearhead the development of a strategy for cassava.
Key members of the Task Force included:

- Cheikh Sourang, IFAD
- Andrew Westby, NRI
- Troude, CIRAD
- Mpoko Bokanga, IITA
- Rupert Best and Guy Henry, CIAT
- Ann Marie Thro, CBN

Through time there have been some changes. Guy Henry replaced Troude from CIRAD, CBN was combined with CIAT and FAO became a member of the task force.

The chronology of events following the May 1996 meeting is outlined below. February 1997 the Intergovernmental Group on Grains recommended that FAO cooperate closely with the IFAD global cassava strategy task force. At the same meeting the Group on Grains agreed to extend its Terms of Reference to include roots, tubers and pulses:

> *"The Group shall include in its field of competence roots, tubers and pulses, exclusively for securing funding for commodity development purposes from the Common Fund for Commodities and, possibly, other financing agencies". The Group also endorsed five new project ideas, including three for cassava: Integrated Research and Development Project for the Development and Value- Adding of Cassava Products in China and South Asia Region; Cassava Market Information and Promotion Service; and Expanding Cassava Utilization for Food, Feed and Industrial Applications in Africa. The Group also endorsed the commodity development strategy for cassava as an essential prerequisite for the Fund's giving consideration to projects for any commodity. (Working Group on International Agricultural Research 1997)*

In June of 1997, IFAD sponsored the Global Cassava Development Strategy Progress Review Workshop. The agenda of the Workshop included discussion of:

- the formulation of the global strategy
- a prospective implementation plan
- the design and scope of relevant cassava-related R & D projects, and

- confirmation of the relevance of roots and tubers, especially cassava, as a possible entry point in developing a country or regional strategy, with special reference to specific ecological zones or socio-geographic communities, either from the viewpoint of food security or income generation and economic diversification.

Input for the Rome Workshop was in the form of comprehensive reports on the status of cassava in the three major producing continents, Africa, Asia, and Latin America and the Caribbean, and selected country-specific papers.

In November 1997 two consultants were contracted to draft *A Global Strategy for Cassava: Transforming a Traditional Tropical Root Crop.* This draft Strategy has been review by stakeholders at a series of regional meetings. The final strategy document, containing inputs and feedback from the regional meetings, will be presented and discussed in a Global Forum to be held later in 1999.

In December 1997 Food and Agricultural Organization (FAO) contracted The European Group on Roots, Tubers and Plantain to prepare a report on *Global Cassava End-Uses and Markets: Current Situation and Recommendations for Further Study.* This reports is also referred to as Phase I.

In January 1998 International Development Research Centre (IDRC), with support from IFAD, contracted dTp Studies Inc. to co-ordinate this study, *Global Cassava Market Study: Business Opportunities for the Use of Cassava,* referred to as Phase II.

The objective of this study *is to identify viable business opportunities for the use of cassava, with the input of industry, traders and producing countries*.

In March 1998 dTp Studies Inc. contracted Dr. Guy Henry, Centre for International Cooperation and Research for Development (CIRAD), to co-ordinate the study of European, African and Brazilian markets. CIRAD solicited the assistance of Drs. Andrew Westby and Andrew Graffham, National Resources Institute, to undertake the African studies; and Drs. Olivier Vilpoux and Marco Tulio Ospina, State University of Saõ Paulo, to undertake the Brazilian study. Dr. Boonjit Titapiwatanakun was contracted by dTp Studies Inc. to undertake the study of the Thai markets.

Collectively, the contracted parties decided to focus on the development and growth of products that are based on cassava. We attempted to avoid duplicating data and descriptions of recent global developments in cassava, which were presented at the IFAD Workshop and in the Phase I report. Our goals were to describe how specific cassava product markets have evolved, to identify the key factors that contributed to the growth of these markets; and to identify who were the major stakeholders in this evolution. This approach is consistent with IFAD's *Global Strategy for Cassava*.

Our intention was not to be prescriptive for specific countries, but to feature opportunities that could be worthy of consideration and development for all cassava producing countries. We are convinced that cassava can be an engine of growth in many cassava-producing countries. The nature and magnitude of contribution must be studied on a location-by-location basis.

Our task was difficult, owing to the multitude of products that can be produced from cassava. Following the approach suggested by the Thai Tapioca Development Institute, we categorised markets in terms of the form that cassava is used as an input: roots or dried roots; native starch; and modified starch. The first category *Produced from Roots or Dried Roots* refers to the production of products directly from cassava, normally using a chipping, grinding or milling process. This category also includes the consumption of fresh cassava for food that would entail peeling the root. The second and third processing categories *Produced from starch - native or modified* refer to a process of removing the starch from cassava by some soaking and separation. Modified starch can be produced from native starch or produced directly from roots. The modifying process changes the physical characteristics of starch – i.e., molecular size, viscosity, and sheer strength.

The complexity of the problem increases as we examine each of the application areas that use, or can use, cassava. For example in the paper industry cassava starch can be used from the beginning to ending stages of paper manufacturing, with different starch characteristics being required. Likewise in food preparation the uses of cassava starch can vary from being a binder, which holds the main ingredients together, to the basis of a sauce, to being an extruded product.

A final complexity is that cassava products are not unique products. For example starches can, and are, produced from a number of cereals and tubers. The food scientists and chemical engineers are able to duplicate the desirable starch characteristics from various cereals and tubers. When the food scientists and chemical engineers cannot produce the desired characteristics plant breeders can breed a new plant that has the desired characteristics. For example, the development of waxy maize in the United States as a replacement for cassava starch (see Chapter VI). Thus cassava and cassava-derived products always face competition.

This report has two parts. Part 1 refers to domestic market opportunities for cassava. Part 2 refers to export market opportunities for cassava. Within each Part the main cassava markets are examined: fresh and processed cassava, cassava flour, cassava starch and cassava chips for animal feed. Within each of these chapters a global perspective or overview is provided followed by individual country case studies. These case studies are from Europe, North America, Africa, Brazil and Thailand. The authors of the case studies were asked to use the following outline:

- Current Situation
- Growth Trends - Physical and Economic
- Determinants
- Bottlenecks
- Role of Stakeholders
- Market Potential and Growth

We apologise if this has resulted in a somewhat stilted style of presentations, but we feel that it allowed us to have relatively comparable information in each of the case studies.

The document is the culmination of many individual efforts. The following table details the various authors and their region of study for this report.

Authors	Contributions
Guy Henry CIRAD-AMIS, PROSPER-PROAMYL Rua Paulo Castro Pupo Nogueira, 600 Campinas-SP, CEP 13092-400, Brasil	Sections on the European Markets
Dr. Andrew Graffham Dr. Andrew Westby Natural Resources Institute Central Avenue, Chatham ME4 4TB United Kingdom	Sections on African Markets
Olivier Vilpoux, Marco Tulio Ospina, CERAT/UNESP Sao Paulo, Brazil	Sections on Brazilian Markets
Boonjit Titapiwatanakun Ph.D. Kasetsart University Bangkok, Thailand	Sections on Thai Markets
Daphne S. Taylor Truman P. Phillips dTp Studies Inc. Guelph, Ontario Canada	Sections on North American Markets
Truman P. Phillips dTp Studies Inc. Guelph, Ontario Canada	Overview on Producing Country Potential

Part 1: Domestic Market Opportunities

Truman P. Phillips

The success and growth in demand for cassava chips and pellets, and cassava starch in non-producing countries suggests that demand opportunities for cassava should be equal, or greater, in cassava producing countries. Much of this opportunity exists because there are new and growing industries that could use cassava and cassava products, and/or there are import substitution opportunities. The following chapters in Part 1 contain an examination of the opportunities for cassava, cassava flour, cassava starch and cassava chips in **cassava producing countries**.

The description and analysis of the global opportunities for cassava is based primarily on data available from FAOSTAT website (FAO 99). This global analysis includes data from 64 countries that produced more than 10,000 metric tonnes of cassava in 1995[1]. Geographically this includes 31 African countries, 11 Asian countries, 19 Latin American and Caribbean countries, and three countries from Oceania. These 64 countries accounted for 99 percent of world production in 1995.

Continental trends in production are presented in Table 1. Only Africa has shown a continued expansion in production over the 34-year period. Asia has had the most dramatic increase in production but level of production has levelled off since 1990. For Latin America and Oceania there has been a slight decline in production since 1970.

Table 1: Regional Cassava Production for the 64 Studied Countries (1,000 mt)

Region	1961	1970	1980	1990	1995
Africa	31,276	40,296	48,149	70,178	83,943
Asia	17,986	23,108	45,919	49,804	48,151
Latin America	21,525	34,640	29,817	32,170	32,509
Oceania	132	164	122	162	167
Total	70,921	98,210	124,009	152,316	164,773

Source: (FAO 99)

To the extent that generalizations are valid, it can be suggested that the differences in continental cassava production trends reflect the different roles of cassava in each continent. African growth is associated with population growth and the importance of cassava in the 31 studied countries. Latin American and Oceania declines are explained by the growth in consumption of alternative stables. Asian growth is primarily in response to the European demand for cassava as energy-rich feed ingredients in animal feeds. The

[1] Omitted from this analysis are countries which in the 'seventies reportedly had annual cassava production greater than 10,000, but are now below this amount. For example: Burkina Faso, Honduras, Mexico, Mali and Sudan.

levelling of European demand in the nineties is reflected in the plateau of Asian cassava production since 1990.

This initial data suggests that the domestic market has been and continues to offer potential for growth in Africa. This is in contrast to Asia and Latin America where reliance on the domestic market is not likely to provide a growth market for cassava. One avenue of growth would be to promote cassava as an import substitution crop. Prime targets for imports substitution could be wheat and wheat flour; maize; maize starch; dextrin, modified starches, glucose, and dextrose.

The following four chapters provide a brief evaluation of the import substitution opportunities for cassava. The chapters also contain case studies that look at specific market development opportunities and how them might be realized.

Chapter I: Cassava Foods

Global Opportunities

Truman P. Phillips

Historically cassava has been first and foremost a basic staple in cassava producing countries. Although cassava can be prepared in a large variety of ways for human consumption, most localities rely on a limited number of preparation and processing methods. It is a point of interest why *new* processing and preparation methods have not been more widely disseminated and adopted.

The importance, or non-importance, of cassava as a human food is portrayed in Table I-1. The most striking feature of Table I-1 is Africa's substantially higher and steady level of cassava consumption (note: these data refer only to those 64 countries that produce more than 10,000 mt of cassava annually). To express the African consumption level in different terms, daily cassava consumption is .4 kilograms per person. This is greater than the daily consumption level of most staples in any part of the world. The message is that cassava is a very important food crop in the 31 African countries being considered.

Table I-1: Annual per capita cassava consumption (kg/year)

Region	1961	1970	1980	1990	1995
Africa	152.67	149.26	139.03	146.23	146.86
Asia	9.69	9.15	10.83	7.74	8.50
Latin America	46.03	57.37	40.58	35.28	33.14
Oceania	44.14	41.83	24.43	24.47	22.84

The Latin American consumption levels, while much lower than in Africa, suggests that cassava is an important human food crop. The consumption of 33.14 kg/year of cassava is higher than the average potato consumption level in Latin America. However, it is lower than the consumption of wheat and wheat products or maize and maize products (FAO 1997).

It is well documented that developing countries have generally had higher population growth rates than developed countries. What is often overlooked is that urban growth rates in developing countries exceed general population growth rates for the four regions (Table I-2). In fact the 64 studied countries include some of the fastest growing countries in the world.

Table I-2: Index of Urban growth (1961=100)

	Urban Population Index				Population
Region	1970	1980	1990	1995	1995
Africa	168.09	287.65	479.52	617.53	260
Asia	125.23	176.85	261.21	311.98	195
Latin America	145.13	209.15	281.60	318.73	211
Oceania	228.95	349.47	471.05	552.11	213

Source: (FAO 99).

Because of higher population growth rates and higher levels of cassava consumption the greatest growth potential for the use of cassava as a human food appears to exist in Africa. Asia has shown some signs of growth and Latin America a slight decline (Figure I-1). (North America and Oceania are not included in this graph because their levels are insignificant when compared to the other three regions.) Applying simple time trends to these data suggests that by the year 2005 African consumption could be approximately 82 million tonnes, Asian 24 million tonnes and Latin American 13 million tonnes. This represents an increase of approximately 21 million tonnes over the 1995 consumption levels. This estimate is close to the FAO estimate of a 26 million tonne increase between the early nineties to 2005 (FAO 1997). The FAO study was more detailed, including income and demographic factors and covering all cassava producing countries.

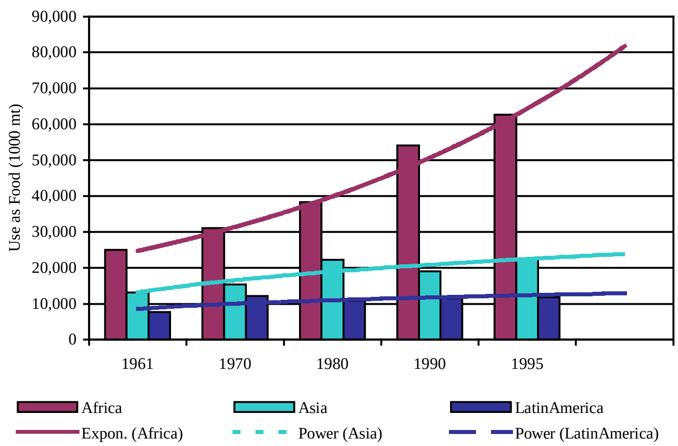

Figure I-1: Regional trends in use of cassava as food to 2005

Demographic changes provide both a challenge and an opportunity for increased demand for cassava as a human food. On the one hand, individuals migrating to urban areas may have less desire to eat cassava than they did when they lived in the rural areas. On the other hand, the increasing urban population provides an opportunity to sell more cassava if the product and price are right. Domestically there are opportunities to develop new, or unexploited markets for cassava. For example growing urbanisation provides a potential new and expanding market for foods made from cassava.

The keys to realising this opportunity are:

- continued consumption of cassava by urban dwellers;
- a distribution system that links producers to urban consumers;
- and a consistent supply of good quality products at a competitive price.

These keys may require improved infrastructure, new handling and storage technologies, increased production and improved efficiency.

While the growth potential resulting from urbanisation is an unknown, several assumptions can be used to provide an estimate of the potential in the year 2005. For this report it is assumed that those people moving to urban areas will maintain their cassava consumption level at the current national consumption level, and that growth in urbanisation will continue at the rate that has existed for the past 10 years. Thus the increased demand for cassava in Africa in 2005 could be 13 million tonnes or a 16 percent increase over 1995 production, given urban cassava consumption of 146 kg/yr and urban expansion at 5 percent per year.

Table I-3: Potential market increase owing to urban growth by region in the year 2005 (1000 mt)

Region	Extra Demand in 2005	% Production Increase over 1995 levels
Africa	13,109	16%
Asia	2,833	6%
Latin America	2,442	8%

This approach was applied to Asia and Latin America to provide the following estimates potential market increase owing to urban growth: 2.8 million tonnes (six percent of 1995 production) for Asia, and 2.4 million tonnes (eight percent of 1995 production) for Latin America. Clearly the market increase potential in Africa is substantial.

Applying this approach[2] to country level data produces Table I-4. For nine of the studied African countries the growth potential by 2005, owing to urbanisation, could be an increase of more than 20 percent over 1995 production levels. Only four other countries, Malaysia, Philippines, Dominican Republic and Venezuela would appear to have such a large growth potential. Nevertheless, the urban market does appear to offer growth opportunity of at least 10 percent for 39 of the countries studied.

[2] The calculation is (extra urban food) = (per capita consumption) * (urban growth rate 1985 to 1995) * (urban population 1995). The second calculation is (% production increase) =100 * (extra urban food)/(total production 1995).

Table I-4: Potential market increase owing to urban growth in the year 2005 (1000 mt)

Country	Extra Demand in 2005	% Production Increase over 1995 levels
Africa		
Mozambique	1,642.42	45.66%
Congo, Rep	255.07	36.44%
Guinea	172.91	28.76%
Angola	574.44	23.94%
Kenya	190.12	22.63%
Cote d'Ivoire	345.56	22.08%
Cameroon	300.49	21.46%
Tanzania	1,250.94	20.96%
Comoros	9.94	20.29%
Zimbabwe	29.09	19.40%
Madagascar	417.98	17.42%
Nigeria	5,168.56	16.46%
Senegal	8.94	16.10%
Sierra Leone	31.15	14.21%
Congo, Dem R	2,681.47	14.19%
Togo	83.23	13.82%
Zambia	67.15	12.91%
Benin	164.84	12.28%
Ghana	801.55	12.12%
Guinea Bissau	1.32	11.96%
Niger	25.93	11.53%
Cent Afr Rep	56.53	11.50%
Gabon	26.28	11.43%
Somalia	3.42	8.55%
Chad	21.78	8.13%
Uganda	136.25	6.13%
Burundi	27.40	5.47%
Malawi	9.00	4.74%
Asia		
Philippines	498.74	25.49%
Malaysia	96.73	21.99%
Cambodia	13.64	16.64%
Laos	9.96	14.55%
Indonesia	2,165.39	14.02%
Myanmar	5.32	7.84%
India	464.41	7.83%
China	234.05	6.69%
Vietnam	124.99	5.65%
Sri Lanka	9.67	3.33%
Thailand	11.43	0.06%
Latin America		
Dominican Rp	30.33	22.17%
Venezuela	65.34	21.83%
Ecuador	13.85	18.30%
El Salvador	6.00	18.23%

Country	Extra Demand in 2005	% Production Increase over 1995 levels
Guatemala	2.82	17.69%
Nicaragua	8.85	17.18%
Fr Guiana	2.99	16.63%
Colombia	289.58	16.53%
Peru	86.43	15.79%
Bolivia	41.53	14.04%
Panama	3.65	11.55%
Cuba	18.30	7.32%
Argentina	11.36	7.10%
Brazil	1,761.71	6.96%
Paraguay	198.24	6.61%
Guyana	1.96	5.60%
Jamaica	0.61	3.52%
Costa Rica	1.44	1.15%
Oceania		
Fiji	2.21	8.64%
Papua N Guin	6.76	5.93%

Case Study: Brazil

Olivier Vilpoux and Marco Tulio Ospina

The previous analysis suggests that the growth potential for cassava owing to urbanisation in Brazil might only be 6.9 percent, or 1.76 million tonnes. While the percentage is not great, the volume is substantial. The Brazilian case studies, which follow, provide an indication of how the urban markets can provide new and growing opportunities for cassava. The case studies also indicate the importance of developing new products, methods of processing and distributions to market growth.

The Brazilian case studies include some of the most progressive food markets in the world. These markets represent relatively high value added cassava markets with comprehensive distribution systems. These markets also have a high level of product recognition.

1.1. Fast Food

The main cassava-based fast food in Brazil is “Pão de queijo”. This is a type of bread made from sour cassava starch, cheese and eggs. Sour starch is a starch that has been fermented and sun dried. Fermentation lasts anywhere from 2 weeks to more than a year. The combined action of fermentation and sun drying induces a physical-chemical modification, giving the expanded starch proprieties that resemble extruded starches.

It is possible to find “pães de queijo” (cheese breads) in many Latin American countries, but its consumption is greatest in Brazil, mainly in the Southern and Centre-western regions, and in Colombia, where it is called “pandebono”.

During the last 5 years Brazilian consumption of “pão de queijo” has increased greatly, changing from a regional product to a nation-wide fast food. During this time, production of “pão de queijo” has also changed from its original recipes. In some cases native and modified cassava starches have substituted sour cassava starch. Also during this time, the sour cassava starch industry has been undergoing a change. For example, production by traditional small-scale starch manufacturers in the traditional production states of Minas Gerais and Santa Catarina has been declining while larger more modern companies are expanding in Paraná.

In Minas Gerais almost every family has its own recipe, made with sour starch. Sour starch gives the product a strong acid taste. In recent years, consumption of “pão de queijo” has travelled from Minas Gerais to the city of São Paulo and then to the rest of the country. The expansion of consumption is explained by the endorsements made by the former Brazilian president, Itamar Franco, who was from Minas Gerais. He required that “pão de queijo” be present at all official meetings. His government was soon called the “pão de queijo” republic (Pao de queiuo agora globalizado 1997b). By 1998 this typical Brazilian product was seen in other Latin American countries, such as Argentina and Peru. Brazilian products are also being exported to Japan, the United States and Europe, where they seem to be appreciated (A Hungria e apenas o comeco 1998a).

In 1995, Vilpoux undertook a market study of the commercialisation of “pão de queijo” in the city of São Paulo, Brazil. During the study 74 supermarkets were visited, 60 bakeries and 36 coffee shops. He found that “pão de queijo” was sold in 95% of São Paulo city bakeries being sold alone or filled with jam or sausages. In early 1995, the average price of a simple “pão de queijo” was US$0.70 and US$0.95 for a filled one. A simple product weighs around 100 g per unit. On a weekly basis the average São Paulo bakery was selling about 23 kg of “pão de queijo”. The study also found that all the interviewed bakeries were buying their products from wholesalers (Vilpoux et al. 1995).

“Pão de queijo” consumption is seasonal. The product is associated with coffee consumption, which is greater in the winter months. The fact that “pão de queijo” is consumed with coffee explains why consumers are typically adults. Nevertheless, all classes of people, rich and poor, young and old, consume "pão de queijo".

Supermarkets are selling a variety of sweet and sour starch mixes (dry pre-mixes, frozen and refrigerated) to make “pães de queijo” at home. In 1995, dried pre-mixes were present in all supermarkets, unlike the refrigerated product, which was present in only 20% of the shops and frozen product which was present in only 45% of supermarkets. In 55% of the supermarkets managers stated that consumers preferred dry products, only 23% preferred frozen products, and only 3% preferred refrigerated products. By 1998, consumer preference for frozen products has probably increased. Frozen food in Brazil has been the food with the highest consumption increase in 1997 (18.2%), and is gaining space in all supermarkets (Novidades na industria de alimentos 1998b). The space reserved for frozen products was very small in 1995 but has increased in recent years, reflecting changes in Brazilian consumption habits.

In 1995, 65% of the supermarkets managers interviewed thought that the “pão de queijo” market was growing, an evolution that is probably continuing in 1998, mainly for frozen products.

In Brazil, the expanding consumption of “pão de queijo” has had consequences on “pão de queijo” processing and the entire cassava starch industry. “Pão de queijo” is now more than a traditional regional product. It is a fast food, consumed by all classes of population in fast-food restaurants and coffee shops. Large groups of coffee shops now exist in Brazil, such as “Casa de pão de queijo” and “Express pão de queijo”, which are selling fast-food products with coffee, and are specialized in “pão de queijo”. The biggest group, the “Casa de pão de queijo” owns 141 shops in the biggest towns of the country, all of them under franchise, and is opening new shops in Argentina.

Paralleling the development of consumption in coffee shops has been development of frozen products, which facilitate the handling of “pão de queijo” in coffee shops and supermarkets. The two biggest Brazilian companies, the “Forno de Minas” and the “São Geraldo”, are growing very fast and are actually producing monthly shipments of between 300 and 750 tons of frozen “pães de queijo” (Pao de queiuo agora globalizado 1997b). “Forno de Minas” started in 1990 with a production of 40 kg per day and has reached 80 tons in 1997 (*ibid.*). In 1997 its sales totalled 40 million dollars, 10 times more than in 1994 and twice as much as in 1996 (A receita da vovo 1997c). This company started exporting to Italy and Peru, with the expectation of regular sales in 1998. Exports to Argentina are expected in the second half of 1998 (*ibid.*). In Minas Gerais State, the region that originated “pão de queijo”, statistics illustrate 85 producing companies in the city of Belo Horizonte, capital of the State, and 120 more in other parts of the State, most of them informal (Pao de queiuo agora globalizado 1997b).

Coffee shops need products that are easy to cook and handle, without the necessity of adding ingredients. The three main products used by coffee shops, restaurants and bakeries are dry pre-mixes, refrigerated and frozen products. The dry pre-mix is not easy to use because of the necessity to add water, a complication for the shops. This product is used mainly in bakeries, where mixing equipment exists. The frozen product is easy to use, but difficult to transport. It is used in big quantities by some specialized coffee shops networks, with the aim to standardise their products. Most coffee shops use a refrigerated product in packets of 5 kg. The shop needs only to form the product and cook it.

The entrance of big “pão de queijo” companies changed most of the industry. A national company needs a standard product with consistent quality. These criterions are very difficult to maintain in “pão de queijo” production because of the low and unstable quality of cheese, and the low and unstable quality of sour starch.

Cheese and sour starch are important ingredients in the “pão de queijo” industry. The cheese industry in Brazil is becoming more concentrated, with improvement of production. Technology to make good quality cheeses, all year round, is already available in some companies. Sour starch problems are more complex. The product is important because of its expansion characteristics, which result from the combined action of fermentation and sun. The fermentation process is difficult to control for uniformity of product. Product quality depends on microorganisms, themselves depending on temperatures during fermentation. Sun treatment is subject to a lot of contamination, making it difficult to use sour starch in modern food companies.

Natural fermentation can be duplicated by a chemical process, which allows for better quality control, reduced costs and shortened production time. A few enterprises have already begun using the process of adding lactic acid or a mixture of lactic acid and acetic acid in the starch to suppress the fermentation phase. Nevertheless, these products are always sun-dried, limiting the economic scale of production units.

The largest Brazilian Starch Company, Lorenz, is making a totally modified starch, substituting fermentation and sun drying by chemical products. This modified starch is very successful if used quickly, but after a period of storage there are flavour problems and most consumers reject the product. Recently, Lorenz bought the second largest frozen “pão de queijo” producer in Brazil, “São Geraldo”, where they will probably use their modified sour starch technology.

As an alternative to the sour starch quality problems, many “pão de queijo” companies are changing their product recipe by eliminating sour starch. Two substitutions are possible: sweet or pre-gelatinized cassava starches, both of which are produced by large modern companies. These products are well established and allow a stable quality year round, with low microbiologic contamination compatible with international standards. The type of substitution depends on the final product. Pre-gelatinized starch is used in dry pre-mixes, and facilitates “pão de queijo” homemade preparation. INDEMIL, a “farinha” and sour and sweet starch producer produce this pre-mix. Sweet starch substitutes for sour starch in the refrigerated and frozen “pães de queijo”.

Because cassava and cassava transportation represents more than 50% of production costs of sour starch production, an important determinant is the price of "pào de queijo". In addition sour starch production tends to be seasonal, concentrated in the winter months (May to October). In regions like southern Minas Gerais where winter temperatures can be negative and detrimental to cassava production. This leads to price variation (Figure I-2) and a greater need to stock sour starch. Finally, seasonality results in companies using less than full production capacity and facing higher fixed costs per unit of product and higher final product prices. This is in contrast to Centre and North Paraná where companies are working between 10 to 12 months a year (Mosquera and Chacon 1992).

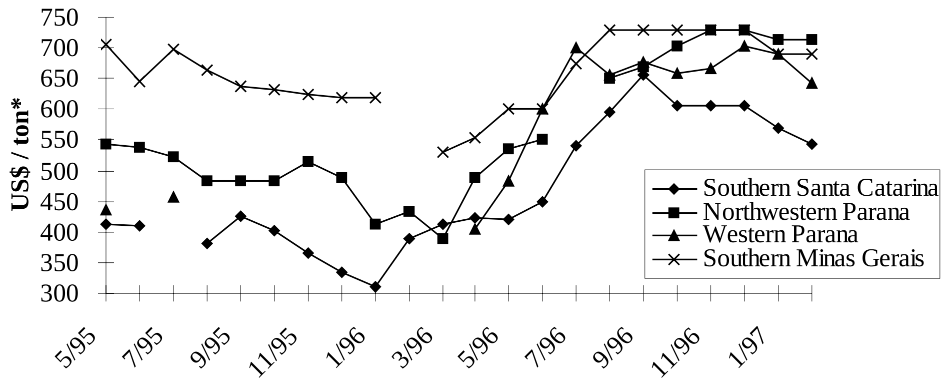

Figure I-2: Evolution of cassava sour starch prices in Brazil (Nominal US$ FOB industry prices)
(Source: Faxjornal, 1995 – 1997)

To better understand the problems of quality and price of sour starch, it is necessary to understand the industrial structure and production process of sour starch.

Sour starch production is a very competitive industry with a large number of small companies (Table I-5). The small capacity limits the possibilities to access modern technologies and market information. This explains in part the problems of quality and price instability. The low educational level of company managers increases the difficulty of using and accessing modern technologies and market information.

More and larger companies are entering in the market, replacing small traditional units. The managers of the bigger companies typically have better education, with better access to market information and modern technology processes. Bigger production leads to a higher financial capacity, with the possibility to invest in the improvement of quality product and stabilisation of price. Higher capacities also allow economics of scale, with price decreases. The larger companies are located in the Paraná State. Sour starch units in Central and North-western Paraná also produce sweet starch with large-capacity modern units.

Table I-5: Number of sour starch units and production in each Brazilian producing region

Regions	Production units number	Production per unit (tons)	Production in the region (tons)
Southern Santa Catarina	33	215	7,095
Central Santa Catarina	2	75	150
Total Santa Catarina	35	-	7,245
Northwestern Paraná	5	1,818	9,090
Central Paraná	1	3,600	3,600
Western Paraná	5	600	3,000
Total Paraná	26	-	18,000
Total São Paulo	1	1,600	1,600
Southern Minas Gerais	60	180	10,800
Total Minas Gerais	100	-	15,000

Source: (Vilpoux 1997)

Processing technology influences product prices and quality. As noted above, cassava root prices influence sour starch costs, but other costs are also important, mainly salaries (Figure I-3). Sour starch production is very labour intensive, limiting its production by large companies. Sun drying forces units to have large drying surfaces and a large labour force to move the product, limiting the growth of production units and entrance of competition.

Even though modified sour starch production has its limitations, its use will probably increase in the future. Some companies, like sweet starch producers, are making advances in new product lines. Modernization of sour starch production, with more expensive technologies, will make it difficult for small units in Brazil to survive. Lorenz has, alone or in joint ventures, three production units in Paraguay and one in Venezuela, and can produce and export sour starch to Colombia's local market. The ownership of "São Geraldo" allows Lorenz to dominate most of the product flow, from raw material to transformation.

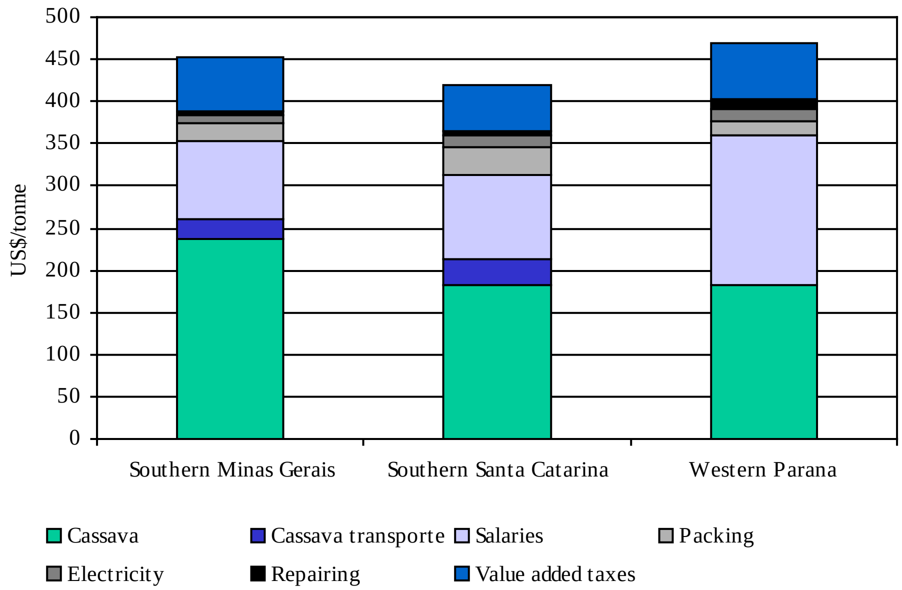

Figure I-3: Sour starch production costs 1997 US$, in 1996, in the main Brazilian production regions
Source:(Vilpoux 1997)

Sour starch gives “pão de queijo” a very acid taste, which is appreciated, in Minas Gerais State. In other States however, where consumption is more recent, people do not like the acid taste and prefer instead a softer product. These preferences facilitate the elimination of sour starch and the substitution of sweet or pre-gelatinized starches. Nevertheless, sour starch is still used by most “pão de queijo” producers, in an average mixture of two-thirds sweet starch to one-third sour starch (Vilpoux et al. 1995). Sour starch is very useful for its expansion properties, giving the product a better appearance. The advantage to substitute sour with sweet starch is not only quality based, but also price based. A ton of sour starch costs between US$500 and 700, compared to a ton of sweet starch that costs between US$300 and 400.

Sour starch remains the dominant starch in the market, but this could change in the future. Sour starch production should improve in quality, regularity of supply and price. If it doesn’t “pão de queijo” companies will continue to try to substitute sour starch with other kinds of raw material. It will be difficult for the smaller companies to follow the larger companies in these changes. An opportunity for research is how to facilitate smaller sour starch companies in finding new technologies that will improve product quality.

These problems are difficult to overcome because of the lack of well-trained and educated managers and the small size of production units and limited financial resources. A solution is to develop better management and organization within companies, provide managers with better skills and education and to diffuse the industry with market and new technologies information. Market information is necessary for production and price stability.

It will also allow smaller companies to have full information on where and for how much to sell their product. Technology diffusion allows quality improvement and production costs to decrease. As for starch production, stabilisation of “pães de queijo” prices could improve cooperation between all members of the agribusiness chain, such as final sellers of product, “pão de queijo” producers, sour starch companies and farmers. Circulation of market information must be improved and production planning must be realised between participants the transformation and commercialisation process.

Cooperation is very important where small companies dominate, as in Southern Minas Gerais and Santa Catarina States in Brazil and other South American Countries, and is also warranted in Centre and North-eastern Paraná, where larger units are present. To address this need, an association was created in 1996 in Southern Minas Gerais, and another one in 1998 in Santa Catarina. To date, their activities are still very limited and the organization includes only sour starch companies, but it is a promising start for future developments.

An improvement in sour starch quality and a decrease in production costs will profit companies of all size. Commercialisation of a cheaper sour starch, with better quality, will develop markets and provide niches for smaller units.

1.2. Snack Foods

Brazil has one main snack food made from cassava called “biscoito de polvilho”, or called “pan de yuca” in Colombia. This product is made from sour starch, eggs and water and is baked like bread. Special sour starch properties allow the product to expand like an extruded food, which justifies its classification as a snack food.

This section is based on the research of Vilpoux previously referred to in the “pão de queijo” section. The “Biscoito de polvilho” industry, similar to the “pão de queijo” industry, has problems with sour starch quality and price stability. These problems are more serious in the “biscoito” industry, as sour starch is the main ingredient and has no substitutes.

Published data and articles on “biscoito” consumption do not exist. The only information about this product comes from Vilpoux study of São Paulo State in the second half of 1994 and the beginning of 1995. Because this market appears to be stable Vilpoux's data is still considered relevant. In 1995, 56% of the interviewed managers of supermarkets stated that they believed the market for “biscoito” was stable. 36% of the managers thought that consumption was growing a little but would stabilize in the near future.

Bakeries, supermarkets and shops in gasoline stations sell “biscoito”. In bakeries and supermarkets the product is less frequently found than “pão de queijo”. Just over 50% of the bakeries were found selling “biscoitos” but 91% of them are selling homemade product. Similarly, supermarkets do not typically sell “biscoitos” (between 30 and 50%, depending of the size of the shop) (Vilpoux et al. 1995).

Children and seniors are the primary consumers of “Biscoito”. More elaborate products, such as snacks from potato or corn, continue to dominate the snack food market even at higher prices. The 1995 study showed greater growth in the consumption for snacks made from corn and potato than snacks made from cassava.

Consumption of “biscoito” is not very great when compared to “pão de queijo” or other snacks. Very small companies are the sole producers of this product. This is in contrast to the production of corn and potato snacks that are made by a few large companies, the biggest being the Elma Chips from the Pescico group. Big companies have national distribution and a known brand. The 1995 study showed that one problem for the “biscoito” industry was the lack of marketing, which is particularly important for commercialization in supermarkets.

Another problem for the consumption of cassava-based snack foods is the quality of product. “Biscoito de polvilho” is naturally expanded, without extruder. Quality of expansion depends of the quality of sour starch, whose problems have already have been discussed above. Other quality problems relate to product conception such as:

Color of the product: yellow in color makes it appear that the product is dirty.

Flavor of the product: all “biscoitos” have the same flavor, which is given by the sour starch. Alternative flavors exist, such as bacon and cheese, but such products are very rare.

Bad quality of packaging: all “biscoitos” have similar packaging, made of transparent gray poor quality plastic, with a few inscriptions. The packages seem dated and do not enhance the inside product.

Cassava-based snacks have faced a lot of difficulties, but stable market opportunities are now appearing. These problems are reviewed here before an analysis of the possible solutions for the development of the industry.

These poor product characteristics and absence of variety prejudice cassava-based snacks, which are typically thought of as a poor person’s product because of their low selling price.

To increase the consumption of “biscoito” it is necessary to change the image of the product. But this change will not be sustainable unless quality control is maintained in the marketplace. The following steps are suggested:

New recipes: develop products with different flavors that will influence customer preferences.

New packaging: develop modern packaging that gives the appearance of a modern product that can be consumed by all kinds of people.

New products: develop a more regular product with an agreeable colour. Experiment with different forms of cassava based snack products that can compete against existing potato and corn snack products.

Because most cassava based snack companies are too small to finance research and development, improvements have been undertaken by technical researchers at CERAT in São Paulo State, CTAA/EMBRAPA in Rio de Janeiro and CIAT in Colombia, in collaboration with market studies to identify consumers preferences. Ideally, "Biscoito" producers should be extensively involved to allow better adoption of new products by the industry. Producers think of marketing strategies to increase their sales only after product improvements have been developed.

The problems encountered by "biscoito de polvilho" ofcompanies, excluding the one linked with sour starch, are quite different from that the problems of other cassava products. "Pão de queijo" and cassava starch are popular products, with great market potential. "Biscoito" on the other hand has a localized market but great potential in the snack food industry. Unfortunately, the product has low quality and is difficult to develop. The first major step to improve the product is to increase quality and improve its form and packaging. Only after such changes, can companies increase this market.

The Colombian "biscoito" is similar to the one sold in Brazil competing in the snack food market alongside corn and potato-based products made by very large companies. The problems faced by cassava snack foods in Brazil are similar to the problems faced in other Latin American countries where similar products exist, and the conclusions made for Brazil would appear to be valid for these other countries.

Another snack food made from cassava is extruded chips, which is sold in Europe and in some Latin American countries. In Europe, these chips are sold in supermarkets, and are very similar to extruded corn products. For example, the Tai-Yang Company makes a prawn-flavoured product in France using Thai cassava starch.

Similar products exist in Brazil and Colombia under the name Mandiopan and Fritopan, respectively. These products are not ready-to-eat. They have to be fried to allow the expansion of the product. The need to deep-fry the product makes it difficult to market. Perhaps the commercialisation of a ready to eat snack in Latin American could be developed as was done in Europe.

Because information on cassava-based snack products is not readily available, this is an area for future study. More information would allow producers to better define the market potential of these products and what has to be done to achieve success.

1.3. Convenience Foods

The growth of the frozen food industry is the result of many factors such as the growth of cities, the distance between work and home and the accelerated pace of human life. Brazilians consume 3.6 million tons of frozen food, which is still very small when compared to the U.S. market of 14.5

million tons (Azevedo 1996). Data from the Brazilian Food Industry Association (ABIA) illustrate that frozen and dehydrated foods are the fastest growing segments of the economy in 1997 (Novidades na industria de alimentos 1998b).

Five years ago, the Agricultural Cooperative of Cotia - CAC was the only large enterprise selling frozen cassava products similar to French-fried potatoes. Today, there are several frozen cassava and cassava-based products in the market, produced and distributed by several different sized enterprises.

Producing a more convenient cassava product, of good quality, at a competitive price could increase fresh cassava consumption. In general three characteristics are important to consumers of frozen cassava products: appropriate price, ease of preparation or consumption (without peeling, cooking or even frying) and good quality (softness, taste and colour).

Using data from the State of São Paulo[3] the per capita cassava consumption is estimated to be 2.5 kg/year with 20% of the production in post-harvest losses. Assuming frozen cassava products are more affordable for higher income groups, the potential demand for such products is estimated at 14 thousand tons per year. According to (Azevedo 1996), the frozen food market in Brazil is concentrated in the large urban centres with 80% of the demand driven by the high social classes. Assuming a plant size of 10 t/day, working 25 days/month and 10 months/year, the market for frozen cassava within the São Paulo State would require at least five processing plants.

Based on São Paulo's estimates an estimate of the nation's frozen cassava demand for the next ten years is between 30 and 50 thousand tons/year. This estimation includes 10 to 15 large Brazilian cities such as Rio de Janeiro, Porto Alegre, Curitiba, Belo Horizonte, Fortaleza and Salvador. Initially, these potential markets may be restricted to only the largest cities since small informal firms close to cassava producing areas may supply the small cities.

In Brazilian supermarkets, the consumer price for frozen French-fried potatoes is US$ 3.37/kg compared to the consumer price for fresh potatoes of US$ 0.75/kg. A similar difference is encountered between frozen cassava and fresh cassava with consumer prices of US$ 2.36/kg and US$ 0.78/kg, respectively. As these two products are easy substitutes, the cheaper price for the frozen cassava product could theoretically allow for greater consumption.

A cassava producer's cooperative (CAU) established a processing plant in 1997 for the production of frozen cassava products with a transformation capacity of six tons of roots/day. Table I-5 illustrates that cooperative prices are 61% higher than those paid by middlemen in traditional fresh markets. The frozen cassava consumer is paying 66 percent more than the fresh

[3] Production of fresh cassava for human consumption in 1994 : 104 thousand tons (Previsao de safra 1997) Population in 1994: 33.5 million people (Pesquisa de condições de vida, 1998) Percentage of families with family income of more than 20 minimum salaries:16,4% (Fundacao Sistema Estadual de Analise de Dados, SEADE). Assuming families of four members

cassava consumer price and 18% of this price corresponds to processing costs. The supermarket margin is greater for traditional cassava than for frozen cassava. Within the frozen cassava market structure middlemen are eliminated but processing costs are high.

Table I-6: Comparative structure of price margins between traditional and frozen cassava markets

	Fresh cassava		Frozen cassava	
	US$/kg	Margin %	US$/kg	Margin %
Farmers selling price	0.034 *	30	0.087	70
Middlemen selling price	0.052	53	-	
Cooperative selling price	-	-	0.87**	41
Supermarket selling price	0.78	93	2.36	63

Source: Data was directly taken from CAU cooperative and supermarkets in São Paulo, 1998
*assuming production costs of US$ 0.026/kg (Vilpoux 1998)
** Including processing costs of US$ 0,43/kg. (Exchange rate US$ 1 = R$ 1.15).

The CONGELAGRO enterprise in Colombia produces the cassava-based product called "croquette" with a consumer price of almost US$ 2. This enterprise uses the individual quick frozen (IQF) process, which substantially increases the processing, costs. Although they have some problems in raw material supply, in general their product is well positioned in the market.

The process developed by Cereda and colleagues, uses a pricking operation before freezing the product. This is a process that requires an intense use of hand labour since specialized machines for cassava peeling or cutting are very expensive. The fresh roots first undergo a washing pre-peeling treatment in a tumbling washer. During this treatment the dark outer skin of the root is removed. In the next step, the roots are cut in cylindrical pieces and then the thick outside fibrous layer (the cortex) is removed by hand. After cutting, the cylindrical pieces are washed again before transforming them into the final shape. This shape can be semi-cylindrical or toothpick cassava. A selection of the toothpick cassava will define a second quality cassava that will be used after cooking for elaboration of cassava "mass". Afterwards, the product is pre-cooked in a boiling solution with water, salt and monosodium glutamate. The product is then cooled by submerging it in a cooler tank and placed in trays that will go for a pre-frozen period in the container. After this period the toothpick cassava and the semi-cylindrical pieces are easily handled and packaged (Cereda et al. 1997).

This process was installed by the CAU cooperative at an initial investment of about US$ 31,000.00 plus a rented container and a free building provided by the municipality. Without municipal support it was estimated that the investment for an 8 t/day procession plant would be approximately US$174,000.00 (US$130,000 for a 300 square meter building space with pre-frozen and frozen rooms plus US$44,000 for equipment). A recently installed plant in the State of Paraná had a 300 thousand-dollar investment in a new cassava product. This plant uses a French cooking system with steam and high pressure and temperature with an actual capacity of 120 t/month and predicted potential for the second year of 210 t/month (VAPZA lanca mandioca pronta 1997a).

These high initial investment costs are one of the difficulties encountered for farmers trying to enter the frozen cassava industry. Another constraint facing the frozen cassava industry is the consumer preference for fresh cassava. Some consumers are aware of the cooking quality of frozen cassava while others still believe that frozen foods loose their quality characteristics. Frozen cassava consumption is a new and developing market. Other difficulties emerge in the product distribution and marketing activities because of high transportation costs and the lack of frozen capacity in many markets.

Co-operatives benefit from vertical integration where raw material supplies, planting and harvesting activities can be programmed. On the other hand, the distribution and selling of product cannot be efficiently approached by cassava farmer cooperatives and it is difficult for these cooperatives to reduce processing costs because of the high cost of new technology and equipment. Larger companies may face several challenges with raw material supply but they can make large investments in processing technologies that reduce distribution and selling costs dramatically.

Over time the frozen cassava market has experienced firms constantly leaving and entering. Firms motivated by the increasing demand for frozen foods enter. Firms leave because of a lack of raw material supply and the high costs of processing, distribution and selling. Three types of firms can be identified: (1) large private firms selling cassava and other frozen products, (2) small private firms working in medium-city markets and (3) cooperatives of cassava producers. In the future large firms will try to dominate the market through strategic alliances with cassava suppliers and processors. The CAU cooperative signed a contract, selling 80% of its production to a large frozen products firm, the Pratigel. Small private firms sometimes work informally and will be restricted to a small piece of the market. Cooperatives of cassava farmers will need support from government or private agencies in order to reduce processing costs and to develop technologies and new cassava-based products. In general, promotion will require R&D on the identification of appropriate cassava varieties for human consumption; on technology for cassava processing including peeling, cutting, frying, frozen and storage; on identifying market opportunities; and on identifying areas for cassava production with experienced farmers.

Four or five stakeholders (CAC, CAU, PRATIGEL, and VAPZA) can be identified within the Sào Paulo State market and even if the frozen cassava products of each one differ they are facing difficulties in the market because of high processing and distribution costs.

It will also be difficult to achieve market expansion because the consumer price is still very high and the target consumer group corresponds to high-income classes. The challenge for these enterprises will be to look for cost reducing improvements within the process. The strategy for market expansion is a reduced consumer price for frozen cassava.

Frozen cassava processing has to be improved in order to reduce production costs and consequently to reduce the final price to consumers. As the demand for frozen cassava increases in the future, the key factors for enterprises remaining or entering in the market will be raw material supplies, low processing cost, high processing efficiency and quality and new cassava products development. As large multinational firms, such as Bonduelle, McCain and Fri-D'or, enter the frozen vegetable products market improved marketing strategies and publicity of frozen foods could positively benefit the expansion of the frozen cassava market.

Conclusions

The domestic market for fresh cassava, cassava snack and convenience foods is often overlooked. These markets exist as growth markets in part because of growing urbanisation, and in part because cassava based products can be competitively priced with alternative foods.

The global analysis indicated that the increased demand by 2005 for cassava as a food, owing to urban expansion, could be as much as 16 percent of 1995 production for Africa, 6 percent for Latin America and 8 percent for Asia. The analysis suggested that nine Africa, two Asian and two Latin American countries could experience a growth in demand of more than twenty percent of production by 2005, owing to urbanisation. An additional 26 countries could experience an increase in demand equivalent to 10 percent of production. For this potential to be realised that the food products must be delivered to the urban centres in a form that is appealing, convenient and price competitive. The Brazilian example of "Pão de queijo" demonstrated that cassava based products can enter the mainstream fast food market. The case study also demonstrates that as the market expands issues of quality, ease of use and timeliness become more important. In this case growth is beneficial to cassava producers, but threatens the existence of small-scale processors. If the processors are to continue to exist they need to find and adopt new technologies that insure that their product is of an acceptable and reliable quality. To achieve this end the processors may require assistance in developing new technologies, and may require training to enable them to work effectively in a growing and larger market.

Chapter II: Cassava Flour

Global Opportunities

Truman P. Phillips

Import substitution opportunities for cassava exist in three broad areas - (i) cassava flour, (ii) cassava starch and (iii) animal feed. Cassava flour can be used as a partial replacement for many bakery and pasta products. The process of making cassava flour entails peeling and washing, grating, dewatering pulverizing, drying and milling.

Cassava flour can be used as a partial replacement for imported wheat flour. As can be seen in Table II-1 all regions experienced substantial increases of wheat imports in the 'sixties. Since 1970 growth in wheat imports has been relatively stable except for the sharp increase for Oceania. Per capita wheat imports in 1995 for Latin America and Oceania exceeded cassava consumption. The form of wheat imports varies from country to country. Some countries import wheat flour while other countries import wheat and mill the flour domestically.

Table II-1: Per capita imports of Wheat (kg/year)

Region	1961	1970	1980	1990	1995
Africa	1.18	6.72	10.82	8.20	8.25
Asia	3.20	7.43	8.16	7.77	8.49
Latin America	7.43	24.22	37.22	23.68	35.24
Oceania	6.72	20.02	27.43	26.43	49.01

Source: (FAO 99).

As an initial estimate of the wheat and wheat flour import substitution opportunity for cassava flour it is assumed that 10 percent of current wheat and wheat flour imports could be replaced. (Note that 10 percent is lower than most cassava flour substitution rates used, or recommended in the case studies that follow). It is further assumed that one tonne of cassava flour requires 4 tones of roots. Applying these assumptions to current wheat and wheat flour imports produces Table II-2. The results suggest that replacing wheat imports with cassava flour could regionally increase the demand for cassava by more than 10 percent in all regions, except Africa. The last column is the average price of wheat imports. By way of a simple comparison the import price sets a target for the price of cassava flour. Given the assumptions stated above the implicit price for a tonne of cassava roots plus transportation and processing range from $36 to $63.

Table II-2: Cassava potential based on 10% replacement of wheat imports

Region	Cassava Potential (mt)	% Production Increase over 1995	Average Import Price (US$/mt)
Africa	1,013,206	1.21%	$253.26
Asia	6,458,211	13.41%	$187.55
Latin America	3,595,400	11.06%	$179.90
Oceania	73,103	43.63%	$144.93

When the analysis is applied at the country level one can see that as many as 23 countries could realise at least a 20 percent increase in the demand of cassava as a 10 percent substitute for imported wheat and wheat flour (Table II-3). A majority of these countries are in Latin America. In Africa Senegal, Somalia and Zimbabwe would appear to be the main benefactors. In Asia China, Sri Lanka, Malaysia, Myanmar and Philippines would appear to be the main benefactors. For many of these 23 countries the "target" price for cassava is greater than $50 per tonne. Based on some of the case study information reported in subsequent case studies this target price would appear to be sufficient to promote the use of cassava as a partial substitute for wheat.

Table II-3 : Cassava potential based on 10% wheat replacement (National)

Country	Cassava Potential (mt)	% Production Increase over 1995	Average Wheat Import Price US$/mt
Africa			
Senegal	65,604	118.17%	$241.99
Somalia	13,909	34.77%	$200.68
Zimbabwe	24,821	16.55%	$363.40
Liberia	23,933	9.97%	$199.59
Kenya	78,659	9.36%	$187.20
Guinea-Bissau	919	8.36%	$184.66
Niger	18,434	8.19%	$198.25
Malawi	11,926	6.28%	$142.33
Gabon	13,760	5.98%	$245.98
Guinea	31,234	5.19%	$202.69
Cote d'Ivoire	74,646	4.77%	$228.44
Sierra Leone	9,074	4.14%	$218.80
Congo, Rep	27,016	3.86%	$165.69
Eq Guinea	1,758	3.74%	$179.97
Chad	9,426	3.52%	$279.85
Comoros	1,566	3.20%	$276.92
Angola	72,714	3.03%	$163.84
Togo	15,126	2.51%	$234.51
Zambia	12,585	2.42%	$244.67
Mozambique	69,705	1.94%	$189.90
Rwanda	2,675	1.78%	$237.31
Cameroon	23,867	1.70%	$180.33

Table II-3 : Cassava potential based on 10% wheat replacement (National)

Country	Cassava Potential (mt)	% Production Increase over 1995	Average Wheat Import Price US$/mt
Cent Afr Rep	8,350	1.70%	$270.82
Burundi	5,838	1.16%	$271.27
Madagascar	25,823	1.08%	$209.77
Benin	12,680	0.94%	$215.59
Nigeria	204,055	0.65%	$414.14
Ghana	37,545	0.57%	$220.97
Congo, Dem R	86,014	0.46%	$227.50
Uganda	9,209	0.41%	$206.24
Tanzania	20,320	0.34%	$211.01
Asia			
China	3,645,188	104.12%	$178.78
Sri Lanka	295,172	101.78%	$176.54
Malaysia	322,633	73.33%	$213.86
Myanmar	21,704	31.97%	$213.98
Philippines	614,856	31.43%	$196.11
Indonesia	1,229,875	7.97%	$198.20
Viet Nam	133,261	6.03%	$192.19
Cambodia	4,300	5.25%	$277.68
Laos	1,718	2.51%	$334.84
Thailand	186,938	1.03%	$219.90
India	2,560	0.04%	$373.83
Latin America			
Guatemala	67,309	421.95%	$208.33
Jamaica	39,549	226.68%	$163.32
El Salvador	47,936	145.77%	$188.79
Ecuador	90,525	119.61%	$234.38
Venezuela	298,414	99.73%	$186.94
Panama	30,263	95.77%	$209.91
Cuba	237,812	95.13%	$160.94
Peru	321,392	58.71%	$172.25
Dominican Rp	75,034	54.84%	$197.59
Nicaragua	25,936	50.36%	$198.59
Guyana	16,914	48.19%	$198.37
Costa Rica	47,017	37.61%	$213.49
Bolivia	100,730	34.07%	$236.91
Haiti	61,203	17.49%	$225.22
Colombia	285,690	16.31%	$194.96
Fr Guiana	2,190	12.17%	$404.55
Brazil	1,815,532	7.17%	$168.77
Argentina	7,979	4.99%	$230.63
Paraguay	23,965	0.80%	$186.12
Oceania			
Fiji	42,127	164.79%	$127.51
Papua N Guin	29,376	25.77%	$161.14
Tonga	1,598	5.71%	$305.98

Case Study: Ghana

Andrew Graffham and Andrew Westby

Increasing urbanisation has led to a rapid increase in the market for convenience foods such as bread, biscuits, pies and cakes in Ghana. All of these products contain a significant amount of imported wheat in the form of flour. Since 1980 there has been an upward trend in the amount of imports of wheat equivalents (Table II-4). In the 'nineties Ghanaian wheat imports were as high as 300,000 tonnes (Graffham et al. 1997). The vast majority of this is milled locally by one of Ghana's four main wheat millers (Table II-4). Formerly the wheat market in Ghana was closely controlled by the Government but following liberalisation, the millers have been able to source wheat independently on the world market.

Table II-4: The Ghanaian wheat market: key statistics

Year	Wheat imports (tonnes)	Estimate of current wheat milling activity and capacity	
1980	131,000	**Miller**	**Milling activity (mt/yr)**
1981	150,000	Takoradi mills	80,000
1982	120,000	Golden Spoon	45,000
1983	111,000	Irani Brothers	40,000
1984	93,000	GAFCO	80,000
1985	77,000		
1986	75,000		
1987	140,000	**Miller**	**Milling capacity (mt/day)**
1988	170,000	Takoradi mills	1200
1989	154,000	Golden Spoon	150
1990	225,000	Irani Brothers	750
1991	207,100	GAFCO	200
1992	164,800		
1993	248,200		

Source: (Graffham et al. 1997).

The continued depreciation of the Ghanaian Cedi against the US Dollar coupled with increases in US Dollar prices for wheat on the world market has lead to sharp increases in the price of wheat flour in Ghana. In March 1995 the wholesale price for 50kg of wheat flour was 21,000 Cedis; by mid-March 1996 this had increased to 38,725 Cedis per bag. A further increase to 42,000 Cedis for white bread flour was reported in April 1996. In October 1997 the wholesale price for 50kg of wheat flour was 58,000 Cedis. These increases reflect unavoidable economic problems as it is recognised that the wheat flour market is not truly competitive and is likely to be influenced by the political wish to keep prices of food staples low.

Increasing prices and currency devaluation have encouraged food manufacturers in both the formal and informal sectors to look for local alternatives to wheat flour.

Given the ready availability of cassava in Ghana, and the existence of suitable processing technologies, cassava flour would appear to be an obvious choice as a partial substitute for wheat flour. However, manufacturers of food items expressed concern over the quality of cassava flour and consumer acceptability. From past experience, manufacturers associated the name “cassava flour” with poor quality fermented products having a low pH, unpleasant taste, odour and colour. Some manufacturers were concerned that cassava flour would lead to toxicity problems due to the presence of cyanogenic glucosides (Day et al. 1996).

Since 1996 the Natural Resources Institute in collaboration with the Food Research Institute (Ghana) and University of Ghana have been working with biscuits manufactures and several small bakeries in Accra. Together they are working to demonstrate that high quality cassava flour can be produced at an economic price and incorporated in common snack food items such as biscuits and cakes and that products containing cassava flour will be acceptable to consumers in a wide range of socio-economic groups. Market acceptability studies in Greater Accra showed that consumers would accept substitution levels of 35% cassava flour in sweet dough biscuits and 60% cassava flour in hard dough biscuits. However, bakers would never go above 50% in hard dough biscuits because of problems of brittleness with products containing high levels of cassava flour (Ababio 1998).

The project has looked at a range of processing methods for peeled roots of locally available low cyanide varieties, including chipping and grating and sun and artificial drying. All methods gave flours of similar quality but grating resulted in a much higher microbial loading than chipping. Sun-drying greatly reduced the cost of production but increased drying times and risk of spoilage due to changes in weather conditions (Graffham and Dziedzoave 1998) and (Ababio 1998).

Although no formal specification exists for unfermented high quality cassava flour in Ghana, biscuit manufacturers and small bakers involved with the project have defined their requirements (Table II-5).

Table II-5: Proposed specification for cassava flour for use by biscuit manufacturers and bakers in Ghana

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.

Source: Ababio 1998.

This opportunity has been mainly influenced by economic factors, although it would be true to say that improved road infrastructure has increased the potential for development of a processing industry to supply locally produced cassava flour to potential users in urban areas.

The likely physical bottlenecks include access to consistent supplies of high quality cassava, transport and lack of power for processing equipment. However, the results of the analysis presented in the beginning of this Chapter suggest that only a small percent of current cassava production needs to be devoted to the wheat replacement market. Thus the physical bottlenecks relate primarily to the quality of cassava, transportation and processing.

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. In production trials cassava flour was produced for between US$0.13/kg and US$0.22/kg depending on whether sun or oven drying was used. This compared favourably with the wheat flour price of US$1.30/kg. Small bakers are producing sweet dough biscuits that use 0.5kg of wheat flour per kilo of biscuits, thus giving a wheat flour cost of US$0.65. When cassava flour was used to substitute for 35% of the wheat flour, a cost saving of 32% was achieved.

The level of investment required to develop this opportunity will vary between US$2,000 and US$20,000 depending on what type of drying method is employed and whether chips are produced in the field or at a centralized processing site.

This opportunity is likely to be affected by economic factors such as macroeconomic and infrastructure problems affecting end users, raw material price and access to credit to support farmers and primary processors wishing to exploit this opportunity.

To be successful this opportunity requires active support from the potential users of cassava flour who need to demonstrate that a market exists for the product, and to set standards for production. At the present time many prospective processors of cassava flour are reticent about taking up production because it is believed with some justification that the food sector will be unwilling to use cassava flour in its products.

High quality cassava flour has been shown to have both the technical and economic potential to succeed in Ghana as a partial substitute for wheat flour in food products. However, it is unlikely to succeed in practice without considerable promotion and an enabling environment.

Case Study: Nigeria

Andrew Graffham and Andrew Westby

Preparation of flour is one of the traditional ways of preserving and adding value to cassava roots that is practised widely in Africa (Natural Resources Institute 1992). However, cassava flour prepared using traditional methods is often fermented and frequently of poor quality, thus making it unsuitable as a substitute for wheat flour in bakery products.

A combination of increased urbanisation, rising incomes, market promotions and specific policy decisions favoured the importation of large amounts of wheat into Nigeria between 1960 and 1987 (Bokanga and Djoussou 1998). In 1985 Nigeria was the largest importer of wheat in Africa with imports totalling US$37 million, that accounted for 2.2% of the nation's foreign exchange earnings (Djoussou and Bokanga 1997). By 1995 the value of wheat and wheat flour imports exceeded US$293 million (FAOSTAT)

Between 1987 and 1990 the Federal Government of Nigeria banned importation of grain thus drastically reducing consumption of wheat products. According to Djoussou and Bokanga wheat imports recovered when the ban was lifted but overall the trend for wheat imports into Nigeria is one of decline. They attribute the decline in wheat imports to a combination of high prices for imported foods including wheat and wheat products, currency devaluation and a continual fall in real per capita incomes. These circumstances have created a favourable environment for the development and adoption of cheaper locally produced alternatives to wheat flour.

IITA minimised the capital investment requirements for flour production by developing a method that makes use of equipment used for *gari* preparation (Onabalu and Bokanga 1998). The IITA process is summarised in Figure II-1. This technique was shown to be suitable for preparing cassava flour from both sweet and bitter varieties of cassava. Mini chippers were also tried in place of the mechanical grater but were found to be unsuitable for bitter varieties because of insufficient reduction in the concentration of cyanogenic glucosides during processing (Abass, Onabalu, and Bokanga 1997) and (Onabalu and Bokanga 1998). Under optimal conditions (dry sunny weather for sun drying), the IITA technique enables small-scale primary processors to produce high quality unfermented cassava flour that meets industrial users specifications (Table II-6) within one day.

CASSAVA ROOTS

PEEL AND WASH

GRATE (MECHANICAL GRATER)

DEWATER (SCREW OR HYDRAULIC PRESS)

PULVERISE

SUN DRY IN A THIN LAYER

MILL FINELY

PACKAGE

Figure II-1: Production of unfermented cassava flour in Nigeria (Source: Onabalu and Bokanga 1998)

A practical standard for edible cassava flour established by several biscuit manufacturers in Oyo State, Nigeria is given in Table II-7. This standard is less sophisticated than the international standard for edible cassava flour defined by (FAO 1995) but gives a better indication of the practical requirements of users. Manufacturers of bakery products in Nigeria are mainly concerned with acidity, gross contamination and cyanide rather than microbiology or specific pasting characteristics.

Table II-6: Specification for cassava flour used by Nigerian biscuit manufacturers

Parameter	Requirement
Moisture	Dry
Ph	5.0 - 8.0
Colour	White
Odour	None
Taste	Bland or sweet
Sand and other extraneous matter	Absent
Cyanide (maximum)	10mg /kg
Dimensions	Finely milled

Source: (Abass, Onabalu, and Bokanga 1997).

The dissemination phase of the IITA project commenced in December 1994 with the training of 77 women and 3 men who were involved in processing of cassava or preparation of bakery products in Oyo town. In February 1995 a commercial biscuit manufacturer commissioned the trainees to produce an initial batch of high-grade cassava flour for use in product development. By 1997 three biscuit manufacturers, two bread bakeries and several small producers of snack foods had placed regular monthly orders for cassava flour to use as a substitute for wheat flour. A fourth biscuit manufacturer was in the process of product development in 1997. During the same period, IITA provided training to 900 primary processors wishing to manufacture cassava flour. Initially cassava flour sold for 10 Nira/kg but the biscuit manufacturers rapidly established a quality standard with pH as the key factor. To encourage quality the biscuit manufacturers established a system of price premiums based on pH (Table II-7).

Table II-7: Price premiums for cassava flour in Nigeria

PH	Price per Kilo in Nira
<4.8	10.00
4.8 - 5.8	12.00
>5.8	12.5 - 17.5

Source: (Onabalu and Bokanga 1998).

By late 1997 the price for premium quality cassava flour was 30 Nira/kg (US$1.37/kg) for a production cost of 20-30 Nira/kg (US$0.91-1.37) depending on fluctuations in price of cassava roots. Cassava flour can reduce a food manufacturer's bill for flour by as much as 48-50% depending on the degree of substitution. Primary processors normally operate in groups of 14 who share processing equipment. In Oyo State these groups contract directly with the users of cassava flour. According to (Abass, Onabalu, and Bokanga 1997) eleven groups of processors were active in 1997. Seven of these used graters for flour production, one group used a mini chipper and the remaining three groups had access to both graters and chippers. During the dry season a processing group can produce 1000-2000 kg of cassava flour. In the wet season this falls to 100-1000kg per week (*ibid*). Using these figures an individual group member could expect to make a maximum of 714 Nira per tonne of cassava flour (US$32.62) and a maximum income of 1428 Nira per week (US$65.24) depending on level of production and cost of raw material.

Although cassava flour can theoretically be used to substitute for 100% of wheat flour, Nigerian food manufacturers have determined practical limits for a range of food products (Table II-8).

Table II-8: Practical levels of substitution of wheat with cassava flour

Product	Maximum level of substitution of wheat with cassava flour.
Snack foods (chin chin, fish pies, buns and fish rolls)	12.5 - 100% dependent on product and user.
Biscuits	5-25% normal, 60% maximum depending on type of biscuit.
Bread	20% maximum
Noodles	10% maximum

Source: (Abass, Onabalu, and Bokanga 1997)

Cassava flour market opportunity has been mainly influenced by changes in national policy and economic factors but has also been influenced by other factors. These factors include the existence of food processing industries, the ready availability of cassava, the ready access to suitable processing equipment and the acceptance of cassava as a convenience food (as *gari*) by urban and rural consumers.

The major physical bottlenecks for the IITA process are access to processing equipment, power to provide mechanization and reliance on good weather for drying the product. In the Nigerian case, weather appears to be the major bottleneck. It can reduce production rates by 90% and interfere with delivery and reductions in product quality and sale price. Prolonged drying leads to fermentation of the wet mash and a reduction in pH value.

The success of high quality cassava flour as a partial substitute for wheat flour in Nigeria has been mainly due to economic factors and changes in government policy. As long as wheat was readily available at low cost it remained the favoured raw material for bakery products in Nigeria. The ban on importation of cereals between 1987 and 1990 created an environment where manufacturers were forced to look at alternatives to wheat to remain in business regardless of quality and other technical difficulties. Experience gained during this period has lead food manufacturers to more readily accept cassava flour as a cheaper alternative to wheat flour if processors can provide the necessary quality. In the post-ban period Nigeria's economic difficulties, currency devaluation and falling per capita incomes have all helped to maintain interest in cassava flour as a means of continuing to produce competitively priced products. It has been estimated that a reduction in wheat flour imports of 15% through substitution with cassava flour could save Nigeria US$14.8 million per annum in foreign exchange (Djoussou and Bokanga 1997). The net return to processors from this saving would be in the region of US$12.7 million and cassava farmers could expect to receive a gross benefit of US$4.2 million.

Production of cassava flour is a relatively simple procedure requiring access to small amounts of clean water for root washing, and a number of items of processing equipment (Table II-9). A group of 14 processors would require between US$1780 and US$2750 depending on the type of equipment used to produce high quality unfermented cassava flour for human consumption independently. These costs could be reduced if the group could gain access to a central mill facility equipped with hammer mills and possibly mechanical graters as well, or by using a belt drive to power the grater and mill from a single engine.

Table II-9: Equipment required for production of high quality cassava flour

Item		Capacity	Total cost in US$
Mini chipper	-manual -mechanised	30-60kg roots/hr 500-1000kg roots/hr	150 700
Mechanical grater		300-500kg roots/hr	body 320 engine 550
Cassava press:	-Board type (x1) -metal cage (x1) Double screw (x1)	All 50-100kg mash/hr	50 230 250-300
Wooden drying racks (x15)		Not determined	30
Hammer mill (x1)		250-400 kg flour/hr	body = 750 5-8 hp engine = 800
Total cost			US$ 1,780 to 2,750

Source: (Bokanga 1998) & (SIS Engineering (Ghana) Limited 1996)

The primary economic constraints affecting this market opportunity are high raw material costs, which can make production of cassava flour uneconomical and lack of capital available to primary processors for investment in additional items of machinery for production of cassava flour.

The stakeholders in this system are cassava farmers, primary processors and end users of cassava flour. The end users have an important role to play in this system as they provide demand for the product, set quality standards and offer incentives for production of consistent quality. In some cases biscuit manufacturers have collaborated with local NGOs to provide training and support for the primary processors in aspects of quality control and business management. As in the other case studies the processor provides a means for cassava farmers to obtain access to a wider market for their products.

To exploit this market opportunity continued support is required from both government and NGOs to promote the use of cassava flour as a substitute for wheat flour, and to provide training and financial support for primary processors wishing to exploit this opportunity. In the present case IITA have found that soft loans of US$2000 shared between three groups of processors were sufficient. Processors were normally able to pay back the loans over a 12-18 month period. In the Nigerian case, processors normally had access to most of the equipment required. In countries lacking an established processing industry with the relevant equipment, higher levels of loans would be required.

Cassava has advantages as a raw material for flour production because of the ease of processing and low capital investment required in establishing a processing unit. In addition cassava flour has a bland flavour and is thus unlikely to alter the flavour of any product in which it is used. The example from Nigeria appears to have potential for replication elsewhere. The following factors are likely to be important for the success of this opportunity:

Positive environment: There must be a positive economic and policy environment for adoption of cassava flour as a substitute for wheat flour

Consumer Acceptance: Users and consumers must be willing to accept cassava flour in food products.

Reliable Supply: Primary processors must be able to provide a reliable supply of cassava flour of a consistently high quality at a competitive price.

Competitive Price: Cassava roots must be available at a sufficiently low price to undercut imported wheat.

External Support: Government and NGO support needs to be available to promote the acceptability of cassava flour and provide training, financial and technical support to primary users.

Access to Machinery: The success of the Nigerian example was assisted by the fact that it utilised machinery available for processing another product (gari). The same situation may or may not exist in other countries

Conclusions

The import substitution potential of cassava flour for wheat four has long been recognized. However the past availability of wheat and wheat four as food aid and the national policies, such as overvalued currency, has worked against the development of a domestic cassava flour industry. The global analysis at the beginning of this chapter makes a case for the growth opportunity that could result from using cassava flour as an import substitute for wheat and wheat flour. In the case of Asia and Latin America the wheat flour substitution market could be equivalent to an additional 13 and 11 percent of current production. The collective potential impact on the African countries studied is only one percent. When the analysis was carried out at the country level 23 countries were identified as having the possibility of developing a new market that would be equivalent to at least 20 percent of 1995 production. The analysis suggested that the price for cassava roots, processing and transportation could probably be greater than US$50/mt .

Even though the country level analysis did not indicate great potential for the cassava flour market in Ghana and Nigeria, a closer examination of the situation indicated that this market is very promising. Both Ghana and Nigeria, owing to changes in national policies and international prices, are finding cassava flour to be an attractive replacement for wheat and wheat flour imports. The use of cassava flour is more advanced in Nigeria than in Ghana. In both countries further expansion of the markets will require a reliable supply of cassava flour of a consistently high quality at a competitive price. Fortunately the technology to produce cassava flour is simple and easily applied in the two countries. The major bottleneck would appear to be the rapid drying of cassava, throughout the year. This is an area that could benefit by further research and development.

One should not underestimate the benefits of using cassava flour as a wheat flour replacement. As noted in the Chapter, a 15 percent replacement of wheat flour imports could equate to an annual foreign exchange savings of US$14.8 million. Within the country net returns to processors could be US$12.7 million and cassava farmers could expect to receive a gross benefit of US$4.2 million.

Clearly more countries need to examine the potential benefits of replacing wheat and wheat flour imports with cassava flour. As international trade agreements are reached which will probably reduce the availability of wheat as a food aid item and increase the world price of wheat and wheat flour the benefits of using cassava flour should increase.

Chapter III: Cassava Starch

Global Opportunities

Truman P. Phillips

Cassava producing countries also import starch-based products that in many cases could be produced from cassava starch. The following table indicates the value of these imports[4] (Table III-1.). The value of these imports is of an order of magnitude lower than the value of wheat flour or maize imports. Nevertheless these imports may represent fledgling industries that could grow and offer cassava-based products a long future. It should be noted that 1995 imports of glucose and dextrose were approximately two and a half times greater than the 1990 imports. The greatest opportunities appear to exist in Asia, especially in the area of glucose and dextrose production. These products are already being made in Thailand.

Table III-1: Value of imports of starch based products 1995 ($1,000)

Region	Glucose and Dextrose	Dextrin and Other Modified Starches	Maize Starch
Africa	$4,365.	$375.	
Asia	$37,263.	$3,859.	$6,351.
Latin America	$19,221.	$3,589.	$5,765.

The FAO concurs that there may be active growth in the demand for starch (FAO). Their results suggest that global demand for cassava starch could increase at an annual rate of 3.1 percent. The regional growth rates are expected to be for Asia 4.2 percent, Latin America 3.4 percent and Africa 2.3 percent. In value terms the major importers of starch products are the Philippines and Indonesia (Table III-2). The major importers of glucose, dextrin and maize starch listed below could also be considered to be the major candidates for developing domestic based cassava starch industries.

Table III-2: Major importers of glucose, dextrin and maize starch 1995 (US$ 1,000)

Country	Glucose	Dextrin	Maize Starch
Africa			
Kenya	$2,312	$0	$0
Cameroon	$960	$0	$0
Malawi	$265	$0	$0
Madagascar	$260	$0	$0
Senegal	$190	$0	$0

[4] It should be noted that available data indicate that a number of countries do not import starch products. This may be the result of a number of countries recording starch imports as non-specified imports.

Table III-2: Major importers of glucose, dextrin and maize starch 1995 (US$ 1,000)

Country	Glucose	Dextrin	Maize Starch
Zimbabwe	$173	$0	$0
Rwanda	$73	$0	$0
Burundi	$68	$0	$0
Gabon	$41	$208	$0
Zambia	$11	$0	$0
Togo	$9	$0	$0
Cent Afr Rep	$3	$0	$0
Angola	$0	$140	$0
Nigeria	$0	$26	$0
Asia			
Philippines	$19,808	$1,543	$2,070
Indonesia	$8,820	$1,038	$1,432
China	$3,246	$5	$3
Malaysia	$1,959	$1,088	$2,191
Thailand	$1,766	$112	$115
Sri Lanka	$1,491	$0	$466
India	$173	$27	$72
Latin America			
Ecuador	$2,459	$525	$739
Jamaica	$2,375	$77	$328
Colombia	$2,162	$146	$967
Brazil	$2,050	$347	$575
Guatemala	$1,726	$43	$478
Argentina	$1,540	$1,008	$451
El Salvador	$1,482	$40	$19
Costa Rica	$1,421	$39	$1,034
Panama	$950	$118	$795
Venezuela	$903	$523	$48
Peru	$841	$69	$54
Bolivia	$607	$3	$0
Paraguay	$449	$0	$0
Nicaragua	$256	$0	$2
Haiti	$0	$60	$9
Guyana	$0	$0	$22
Dominican Rp	$0	$585	$234

In some countries almost all starches could be replaced with cassava starch, while in other countries very little imported starch can be replaced. This is because starches, such as glucose and dextrose, etc., represent a broad range of products with a multitude of properties. Without information about the specifications and use of imported starches it is difficult to provide estimates of the potential market for import substitution for cassava starch as was done for the other domestic market opportunities.

Case Study: Benin, Ghana and Malawi

Andrew Graffham and Andrew Westby

Starch is an important raw material for a number of industries including textiles, paper, adhesives, pharmaceuticals and food. As a country becomes more industrialised demand for both native and modified starches increases but this demand is typically met through imports rather than locally made starch. This case study looks at the potential production of native cassava starch in Benin, Ghana and Malawi as a substitute for imported products. The first section provides specific details from these three countries. The remainder of the case study deals with general physical and economic factors that are applicable to any nation planning to establish a cassava starch industry.

The information on Benin is derived from a feasibility study carried out by CIRAD on behalf of FAO (Faure 1993), information on Ghana comes from DFID funded studies carried out by NRI (Day et al. 1996) and (Graffham et al. 1997), and information on Malawi comes from an IDRC funded project carried out by the University of Malawi (Fabiano 1998).

1.1. Benin

In 1993 Benin imported 120 tonnes of starch for use mainly in textiles, adhesives and food. Most of this came in the form of native starch derived from cassava (30 tonnes from Cote d' Ivoire), sweet potato (30 tonnes from China) and cornstarch (60 tonnes from European Union). Although small amounts of starch were produced locally as by-products of Tapioca and gari production none of this starch was used by industry because potential users perceived it as being of poor quality. Imported starch costs between US$818 - US$940/tonne. Given that fresh cassava roots could be purchased for US$14-21/tonne it was estimated that native cassava starch could be produced locally for between US$264 - US$343/tonne if suitable processing equipment were available. From these figures it would appear that an attractive margin exists for local cassava production. However, the market size is very small with little opportunity for significant growth and the capital investment required to exploit this opportunity would be very high. A small starch factory producing 10 tonnes dry starch per day would produce a years supply of starch in just 10 days and consume only 480 tonnes of fresh roots (national production of ~1,000,000 tonnes/annum).

In 1993 a proposal was made by a joint Beninian and Canadian company (Bencan Ltd) to establish a cassava starch factory in Ketou to produce 9,500 tonnes of dry starch/annum from 50,000 tonnes of fresh roots/annum. The projected cost of the venture was US$6.8 million (inclusive of capital investment, running costs and civil works). Bencan proposed to supply all national needs and then sell surplus to Japan and Europe to generate foreign exchange (Faure 1993). It is evident from this information that the national market for starch in Benin was too small to support a cassava starch industry. Exports might solve this problem but it should be kept in mind that the world market for starch is highly competitive.

1.2. Ghana

In 1996 the market size for starch in Ghana was some 4,200 tonnes (Table III-3), most of this starch was imported and 60% of the market went to modified starches with high product specifications. A previous survey (Glucoset 1994) predicted that the market had potential to grow to 5,600 tonnes by the year 2000. However, in view of the recent power crisis in Ghana this now seems uncertain.

Price of imported starch ranged from US$470 to US$510/tonne for cassava and maize starch respectively. Imported maize starch based adhesives ranged in price from US$900 to US$1,260 depending on country of origin. Within Ghana only one maize starch company is operational. This company produces maize starch to order at US$700/tonne and currently produces around 400 tonnes/annum. The owner of this company formerly produced cassava starch but switched to maize on the basis of increased durability and lower moisture content. Although the local maize starch appears expensive it finds a ready market because the local product is not susceptible to the vagaries of the import system.

Two companies produce flour like products from cassava, which are sold as pure starch. One of these companies has a very poor track record and has difficulty marketing its product at US$350/tonne. The other company sells an inferior grade of paperboard adhesive for US$430, which is popular with a number of users on the grounds of low price and reasonable product characteristics. In addition small amounts of cassava starch are produced as a by-product of agbelima processing (a fermented food) and are sold for the equivalent of US$320-470/tonne. This product is used by several glue and textile manufactures, but is of very poor quality and only available in relatively small amounts.

Table III-3: Market for starch (maize, cassava & potato) in Ghana in 1996

Sector	Market share (%)	Metric tonnes per annum (estimated)
Textiles	40%	1,680
Pharmaceuticals	20%	840
Paper	10%	420
Food	3%	126
Plywood (glue extenders) + others	27%	1,134
Total		4,200

Source: Graffham et al 1997.

In 1988 a company called Glucoset put forward a proposal for a large cassava starch factory in Volta Region to produce a minimum of 7,000 tonnes of dry starch (native and modified) per year. The proposed investment for this project was US$10 million. In 1996 this proposal was still under discussion and funds were being sought.

At the present time the starch market in Ghana is quite small and dominated by modified starches with high quality specifications and thus offers limited scope for local production of cassava starch. However, there is scope to produce high quality cassava flours from dry cassava chips for use in starch based paperboard adhesives and plywood glue extenders. This area is discussed in more detail in the section dealing with opportunities for cassava flour.

1.3. Malawi

In 1997 the market size for starch (excluding food uses) in Malawi was around 780 tonnes (Table III-3), this requirement was met by importing maize starch from South Africa and Zimbabwe for US$650/tonne. All of the manufacturers listed have relatively low specifications and could use locally produced native cassava starch or products derived from cassava starch. As part of an IDRC funded project, the University of Malawi has been collaborating with two local manufacturers of paper board and Forintek Canada (supplier of wood glues) to assess the technical potential for local manufacture of cassava starch and cassava starch based adhesives for the paper board industry. Laboratory and factory trials have shown that locally produced cassava starch can be used to replace 50 to 100% of maize starch in starch-based adhesives. Cassava starch has the added advantage of reducing the amount of sodium hydroxide (gelatinisation modifier) and borax (viscosity enhancer) required to prepare a suitable adhesive for paperboard manufacture, thus further reducing costs. While this project has been essentially a technical and laboratory based, it is hoped that the project will suggest options for commercialising cassava starch production.

Table III-4: Market for starch (maize) in Malawi in 1997

Sector	Market share (%)	Metric tonnes per annum (estimated)
Packaging industries	33%	260
Carton manufacturers	17%	130
Nzeru Radio (dry cells)	17%	130
Plywood	20%	156
Textiles	13%	104
Total		780 metric tonnes

Source: (Fabiano 1998).

1.4. Processing

There are two main methods for industrial processing of native cassava starch. There is the traditional approach favoured in India and some Latin American countries and the modern approach “Alfa Laval type” used for large-scale industrial processes in many parts of the world. A brief description of these two processes is given below with comparative advantages, costs and inputs.

In the traditional process, fresh roots are washed and de-barked before crushing in a rotary rasper (Balagopalan et al. 1988). Starch is separated from the crushed pulp by passing through a series of reciprocating nylon screens of decreasing mesh size (50-250 mesh). The resultant starch milk is settled over a period of 4-8 hours using a shallow settling table or a series of inclined channels laid out in a zigzag pattern. Settled starch is sun dried on large cement drying floors for approximately 8 hours. During this period the moisture content reduces from 45-50% down to 10-12%. To achieve efficient drying sunny conditions are required with ambient temperatures of >30°C and relative humidity of 20-30%. Dried starch is ground to a fine powder and packaged for sale.

In the modern "Alfa Laval type" process, roots are washed and de-barked, sliced and then crushed in a rotary rasper. Starch pulp is passed through two conical rotary extractors to separate starch granules from fibrous materials, and then fed via a protective safety screen and hydrocyclone unit to a continuous centrifuge for washing and concentration. The concentrated starch milk is passed through a rotary vacuum filter to reduce water content to 40-45% and then flash dried. The flash drying reduces moisture content to 10-12% in a few seconds, so starch granules do not heat up and suffer thermal degradation.

A comparison of the traditional and modern processes for cassava starch processing is given in Table III-5.

Table III-5: Comparison of traditional and modern methods for production of native cassava starch

Factor	Traditional factory processing 4,000 tonnes roots/annum	Modern factory processing 42,000 tonnes roots/annum
Quantity of roots processed in tonnes	4,000 tonnes per annum	42,000 tonnes per annum
Quantity of dry starch produced in tonnes	1,000 tonnes per annum	10,500 tonnes per annum
Processing capacity (tonnes of roots per hour)	4.5 tonnes roots/hour	6.0 tonnes roots/hour
Total process time from fresh roots to dry starch	2 days	1 hour
Capital cost for basic equipment[1]	US$25,000	US$2.5million
Pay off period[2]	1-2 years	2-5 years
Minimum operating season for economic return[3]	4-6 months/year	10 months/year
Materials used for construction[4]	Mild steel to reduce costs at expense of slight discoloration of product.	Stainless steel to avoid colour problems.
Water consumption without water conservation	7.5m^3 per tonne of roots	5.5m^3 per tonne of roots

Factor	Traditional factory processing 4,000 tonnes roots/annum	Modern factory processing 42,000 tonnes roots/annum
Water consumption with water conservation	3.0m^3 per tonne of roots	1.5m^3 per tonne of roots
Power consumption	20kW per tonne of roots	75kW per tonne of roots
Fuel oil for flash dryer	Not applicable	18kg per tonne of roots
Sulphur for sulphur dioxide generator	Not applicable	1.1kg per tonne of roots
Land requirement	Large - space is required for settling tanks and drying yards.	Small - factory is compact and can be contained in one building.
Labour requirement	Semi skilled labour to operate and maintain factory.	Skilled labour to operate and maintain factory.
Quality of starch	High quality but not as good as product from modern factory. Starch loses some quality because of long process time.	Highest quality possible but depends on quality of roots used.

Source: (Trim and Curran 1993), (Alfa Laval Limited 1992) and (Nivoba Engineering 1995).

1. These figures are for basic equipment costs and exclude transportation and customs duties, civil works, purchase of land, labour and ancillary structures.
2. The pay off period will be determined by the profitability of the factory that is mainly determined by costs of raw materials, utilities and electrical power.
3. This is the minimum operating season required for the factory to provide an economic return.
4. When cassava is crushed hydrocyanic acid is released which can react with iron components in the factory to form ferricyanide complexes that give the starch a bluish shade when wet. This can be avoided by using stainless steel fittings or peeling roots, and can be reduced by using flexible plastic pipes where possible and operating a regular maintenance schedule.

The modern process has the advantage of a very short processing time and excellent product quality. However, modern factories require a high level of capital investment, are costly to operate and require highly skilled labour to maintain the equipment. In addition a reliable electricity supply must be available throughout the process.

In contrast, the traditional factory offers greatly reduced capital and operating costs at the expense of a longer processing time and some loss of quality. In practice the quality is sufficient to meet the specifications of food, pharmaceutical and textile industries in India and Latin America and thus unlikely to limit access to either national or export markets. In the traditional factory electricity is only required for rasping and filtration, settling relies on gravity and drying using solar energy. This can be useful in areas where electricity is in short supply, and also helps to greatly reduce operating costs. The downside of the traditional factory is the large area of land required and the need for more regular maintenance to replace mild steel, plastic and nylon parts that are much less durable than stainless steel.

Overall it can be seen that the choice of method will depend on local conditions, availability of capital, scale of production and quality of starch required. Only Ghana would currently appear to have a sufficient market to suggest considering establishing a "modern" starch factory.

The precise specification for cassava starch will vary according to its intended application. However, starch should always 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 is a key parameter for determining starch quality, specifications vary according to use, but in general it would be fair to say that a high viscosity indicates good quality whereas low paste viscosity will indicate that the starch undergone some degradation during processing.

1.5. Growth Opportunities

The market opportunity for native cassava starch will exist to some extent in any country that is becoming more industrialised and therefore consuming more starch in various industrial processes. It is assumed that starch processing will be carried out in a factory environment because of the sophisticated equipment requirement. Dry starch can be sold by the factory direct to the end user or further processed at the starch factory. Processing may include conversion into dextrins or formulation into starch based adhesives for the paperboard industry.

The main physical factors that are likely to determine success in exploiting this market opportunity are as follows:

Road infrastructure: A good road infrastructure is required to ensure that cassava roots can reach the factory for processing within 12 hours of harvest.

Cassava supply: To produce high quality cassava starch a reliable supply of roots at optimal maturity of 10-12 months is critical. Immature roots will have high water content and soluble sugars and less starch. Over mature roots will contained reduced amounts of starch of lower quality and high fibre.

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.

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

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

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.

Choice of drying method: Sun drying will reduce costs but increases 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.

Once established a cassava starch factory could face a number of physical bottlenecks that interfere with production, these include:

Cassava supply and seasonality of supply: Starch factories require at least 20-40 tonnes of high quality fresh roots a day for a period of at least 100 days a year to be effective. To supply these demands cassava 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 cassava had always been perceived as a low value, food security or marginal crop. To be effective starch factories need a long processing season with continuous supplies of roots 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 root availability often coincides with periods of wet and cloudy weather which are unsuitable for sun drying.

Root maturity: Starch factories have highly critical requirements in terms of root maturity. However, farmers will be tempted to harvest roots early to maximize use of available land and may occasionally leave roots in the ground for too long in the hope of getting a better price.

Water and power supplies: These two factors are most likely to cause problems during the dry season, and limited supplies of either could disrupt processing.

Cassava: Although popular as a source of starch, cassava roots can be seen as a liability owing to their high degree of perishablity and high water content (70% of fresh weight). As a result there is no margin for error in handling cassava and the high water content introduces the added expense of transporting a large amount of water from field to factory for no useful purpose. This problem might be overcome by producing dry chips but starch recovery and quality from dry chips is poor.

Local processing of native cassava starch is often seen as an attractive option, because it offers a means of converting a relatively low cost raw material into a high value product that can readily substitute for imported starch. In Ghana a local producer of maize starch found that he could price his product at similar levels to the imported products because users valued the guaranteed nature of the local supply and freedom from the problems of importation such as holding of safety stocks and fluctuations in international markets. Starch is also seen as a potential high value foreign exchange earner.

However, to access this market opportunity a high level of investment is required. A traditional factory would require a minimum of US$150,000 to establish. A proposal for a modern starch factory would typically budget for US$8-10million for initial capital investment and significant amounts of additional funding to cover running costs in the first few years of production.

The potential economic bottlenecks for native cassava starch production are as follows:

Capital and running costs: Production of native starch from cassava on an industrial scale requires a high level of capital investment, followed by high running costs. Modern factories may require 5 years to pay off the initial investment (Table III-5) and start providing an economic return. The risk involved in investing in starch production is high because of the number of variables involved.

Market size, access and price competitiveness: In Ghana, Malawi and Benin the national markets for starch remain small and may not grow significantly in the short to medium term due to a combination of macro-economic factors that limit the rate of industrialisation. Given this situation it would be difficult to imagine a modern starch factory providing an economic return by supplying to a purely national market of this size. The alternative may be to aim primarily at the export markets. Cassava starch is versatile material that competes well with maize, wheat and sweet potato starches. However, it should be realised that many markets are not completely open in nature (e.g. European Community) and also that price competition is fierce. Much of the market will be for modified and speciality starches prepared from the cheapest raw material available. To enter any of the markets, be they national or international, the product price and quality must be competitive. Potential users will always aim for the lowest price from reliable sources.

Users perceptions of quality and reliability: In the three countries dealt with in this case study (Benin, Malawi and Ghana) industrial users of starch had attempted to reduce costs by purchasing locally prepared products. These products sold as "cassava starch" generally turn out to be either very poor quality cassava starch produced as a by product of traditional food processes such as *gari* and *agbelima* production, or low grade cassava flours that vary widely in quality from batch to batch. These products did not meet the user's specifications and led users to consider locally produced starches to be of poor quality. New entrants to the market may find it difficult to persuade users that they can deliver a high quality product of consistent quality on a regular basis.

As with other market opportunities native starch production involves a number of stakeholders who all have key roles to play in ensuring successful exploitation of the opportunity. The role of the farmer in this case is to provide a consistent supply of high quality roots harvested at optimum maturity for starch extraction. This may prove to be a novel concept for many farmers who would normally consider cassava as a food security crop that can be harvested at almost any time from 8-24 months. The processor takes responsibility for getting the cassava to the factory within 12 hours and then extracting starch as quickly as possible. To ensure root quality the processor would be advised to provide support to farmers in terms of credit and educate farmers as to the requirements of the factory. To be successful the processor will need a financial backer who is willing to accept that the risks associated with this type of venture. To maximize opportunities within the national markets the processor would be advised to involve local research and development institutes to collaborate with local users of starch in the development of products that make use of locally produced cassava starch.

The international market for starch seems likely to continue to grow, particularly in the area of speciality starches for novel applications in a wide range of manufacturing industries (Jeffcoat 1998). Within this context cassava is likely to continue to have a role as a source of raw material for starch production. However, a would-be entrant to the native starch market in Africa would be well advised not to rely on predictions for the international market but to give serious consideration to the potential for growth of the national market. The size and growth potential of the national market for starch will depend on the level of industrialisation in country and the macroeconomic climate of the nation. For example Ghana has a relatively high level of industrialisation and a good market for starch, which should expand on a long-term basis. However, in the short term problems such as the power crisis and general economic conditions may limit investors willingness to invest in the expansion of the manufacturing sector and thus limit the potential for growth of the starch market.

There are many advantages of cassava for starch production. Cassava offers a relatively cheap source of raw material containing a high concentration of starch (dry matter basis) that can match or better the properties offered by other starches (maize, wheat, sweet potato and rice). Cassava starch is easy to extract using a simple process (when compared to other starches) that can be carried out on a small-scale with limited capital. In addition cassava starch has a high level of purity due to the low levels of proteins and lipids found in cassava roots.

Cassava starch production could have potential with sufficient supplies of raw material and a degree of industrialisation to support a national market for cassava starch. However, potential entrants to this market will only succeed if they have sufficient capital to back the venture, and can deliver reliable supplies of starch that meet the users specifications at a competitive price. If the market is mainly for paperboard and plywood adhesives, which have low specifications, it should be possible to establish a market for products based on high quality cassava flour in place of starch. This option would have the advantage of low capital investment, simpler technology and less critical processing, whilst still creating a competitive product that can replace imported starch and starch based adhesives.

Case Study: Ghana (Adhesives)

Andrew Graffham and Andrew Westby

This section provides a more detailed analysis of one specific market for cassava starch - that of the adhesives market in Ghana.

As noted above, the paperboard and plywood industries of Ghana are significant users of starch, flour and starch based-products. The paperboard industry used 420 tonnes of starch-based adhesives for manufacture of corrugated board in 1996, and the plywood industry used 1,134 tonnes of starch and 1,200 tonnes of food grade wheat flour as extenders for synthetic wood glues in the same period. The paperboard and plywood industries account for 37% (excluding wheat flour) of the market for starch and starch based products in Ghana (Graffham et al. 1997).

There are currently six manufacturers of starch-based adhesives for paperboard in Ghana, half of which prepare some or all of their products using locally produced cassava starch or flour. The paperboard sector comprises four companies who use starch-based adhesives (SBA) in the manufacture of corrugated board. Imported adhesives based on maize starch account for 55% of the market and cost between US$900 and US$1,260/tonne depending on country of origin. The remaining 45% is sold by a local manufacturer of cassava-based adhesives at the equivalent of US$430/tonne (Day et al. 1996). The imported materials are prepared from pure maize starch, and the local product is prepared from a rather poor quality cassava flour derived from unpeeled cassava roots that are sun dried, coarsely milled, screened, and blended with other adhesive components. Both local and imported products are supplied as ready mixed dry powders in 50kg bags.

Three out of the four-paperboard factories use local as well as imported adhesives. The local product is favoured because of its low price and ready availability. However, all users commented unfavourably on the quality of the local product. Locally produced SBAs form weaker bonds, have a short shelf life, contain too many contaminants, and are not finely milled. Users overcome bonding problems by blending local and imported products together (Day et al. 1996).

The plywood industry in Ghana comprises eight large-scale factories, which use imported synthetic resin based glues in the manufacture of plywood sheets. These glues cost US$2,220/tonne. To reduce costs synthetic glues are mixed with an extender that can be either imported maize starch (US$650/tonne) or food grade wheat flour (US$500/tonne). Typically 50kg of synthetic glue will make 55-60 1/8” plywood sheets, with an extender this increases to 80-85 sheets of 1/8” plywood sheet. For each 50 kg batch either 10kg of maize starch or 25kg of wheat flour is required (*ibid*). Several factories have tried locally produced cassava flour and starch as extenders but found these to be of poor quality and discontinued use. Locally produced flour was not milled properly, insufficiently dried and contained many insoluble impurities that caused blistering in the plywood sheets. One manufacturer claims that local flour caused his percentage of rejects to rise from 1 to 7%.

General specifications for SBAs and plywood glue extenders are given in Table III-6. Users of these products are not generally concerned with cyanide content, microbiology, colour, taste or odour but would not expect a product to shown signs of mould. Users of paperboard adhesives may have specifications for shelf life and bonding characteristics but are normally flexible if the price is attractive.

Table III-6: Product specifications for paperboard adhesives and plywood glue extenders

Parameter	Starch based paper board adhesive	Plywood glue extender
Moisture	10-12%	10-12%
Milling quality	Finely milled	Finely milled
Impurities	Free of insoluble impurities	Free of insoluble impurities
Viscosity of cold mix	33-34 Steinhall seconds (minimum = 29 Steinhall seconds)	Not specified
Pasting temperature	63-66°C	Not specified

Source: (Graffham and Dziedzoave 1998)

The Natural Resources Institute and Food Research Institute (Ghana) have followed two approaches for production of cassava chips (Fig. III-1) that can ultimately be milled into flour for industrial use at a centralized processing facility. The first approach focuses on field-based production of cassava chips by farmers; the second makes use of a centralized processing facility with higher levels of mechanization and mechanical drying. The NRI/FRI process uses modified IITA mini chippers as these provide chips that dry in the shortest possible time. The farm-based option has the advantage of low cost (US$65/tonne)[5] and produces chips of sufficient quality if some measure of quality control is in place. The centralized option for chip production is more suited for large-scale production of consistent quality chips, albeit at much higher cost (US$217). In many cases field-based production of chips would be appropriate followed by milling and formulation (for SBAs) in a centralized facility such as a flourmill or glue factory.

[5] Chips are purchased at this price from farmers co-operatives who normally produce chips for livestock feed purposes, the nominal price for chips is US$40/tonne but higher prices ensure quality and reliability.

Field based | **Centrally based**

Cassava roots
(Washed but not peeled)

↙ ↘

chip manually | Mechanised chipping

↓ ↓

Sun dry on raised tray for one day, and plastic sheet for one day | Artificial drying for 8 hours at 55°C or sun drying

↘ ↙

mill finely
(using hammer mill)

↓

screen through stainless steel mesh
(1mm, 430µm & 250µm)

↓

Package

Figure III-1: Options for production of unfermented cassava flour for industrial use (Source: Source: Graffham & Dziedzoave (1998))

Starch based adhesives in the manufacture of paperboard consist mainly of starch or flour blended with certain chemicals (Table III-7). The essential ingredients in starch-based adhesives (SBA) are starch/flour, gelatinisation modifier (sodium hydroxide), viscosity enhancer/stabiliser (borax) and preservative (sodium formaldehyde). A basic formulation for 1 tonne of SBA in dry form could be as follows:

Starch/flour (96.4%)	*964 kg*
Sodium hydroxide (1%)	*10 kg*
Borax (2.5%)	*25 kg*
Sodium formaldehyde (0.1%)	*1 kg*

Using the prices given (Table III-7), this product would cost between US$204 and US$350 per tonne depending on the cost of cassava flour. The amount of borax and sodium hydroxide must be determined experimentally so as to provide a SBA with the correct viscosity and pasting temperature to meet the users specification. As the range for these ingredients is quite wide (Table III-7), costs could be considerably higher in practice.

In addition to the basic ingredients, fillers such as clay or coconut shell are often added, and in some 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 user's requirements.

The chemical cost quoted in Table III-7 only applies to relatively small quantities purchased for trial purposes by NRI/FRI. In commercial practice prices would be much lower because chemicals are normally sold in 16-20 tonne containers at negotiable rates. Price is normally determined by quantity, customer reliability, prevailing exchange rate and shipping cost (Graffham and Dziedzoave 1998).

This market opportunity has been mainly influenced by changes in national policy and economic factors. But it would also be true to say that improvements in the network of major roads linking inland areas of Ghana with the coastal cities and major ports has made cassava more attractive as a raw material for locally produced starch based adhesives and glue extenders.

Current production of cassava based adhesives centres around Central and Ashanti Regions, which have large supplies of cassava, good road infrastructure and easy access to users of these products in Accra, Kumasi and Tema. Cassava chips are sourced directly from the farm and milled and formulated at the adhesive factory. Adhesive suppliers produce and supply adhesives to paperboard factories on a contract basis.

The likely physical bottlenecks affecting this opportunity are access to cassava of sufficient quality for use in SBA production, infrastructure problems and access to technical information required for development of locally produced SBAs that can compete with imported products by providing equivalent quality at a lower price. At the present time Ghanaian manufacturers of SBAs compete well on a cost basis but their products are of inferior quality and that reduces their competitiveness.

Increasing prices for imported materials and a continuing fall in value of the Ghanaian Cedi against the US Dollar have provided an impetus for Ghana's paperboard and plywood industries to look for cheaper locally produced alternatives to imported adhesives and extenders. Commercial adhesive manufacturers have shown that a reasonable product can be prepared from cassava and sold at a third of the price of the imported material.

Table III-7: Materials used in the preparation of starch based adhesives (SBA) for paperboard.

Ingredient	Importance	Cost US$ per kg	Percentage/quantity per tonne of SBA	Cost per tonne of SBA	Comment
Cassava flour	Essential	$0.065-0.217	61.1-96.4% / 611-964kg	$39.72/62.66 - $132.59/209.19	Price is dependant on production cost of flour.
Borax	Essential	$3.33	2-18% / 20-180kg	$66.60 - 599.40	Creates high viscosity stable paste, normally use around 2.5%.
Sodium hydroxide	Essential	$2.66	0.1 -5% / 1-50kg	$2.66 - 133.00	Partially degrades starch to reduce pasting temperature.
Sodium formaldehyde	Essential	$31.93	0.1% / 1kg	$31.93	Improves shelf life of wet paste.
China clay or other filler	Normally used but may not be essential	$8.32	0-10% / 0-100kg	$0.00 - 832.00	Reduces penetration of paste into paper. Using locally available materials can reduce costs.
Aqueous antifoam	Use when necessary	$33.26	0.1% / 1kg maximum	$33.26 maximum	Can often reduce foam by reducing mixer speed.
Sodium bisulphite	Use when necessary	$7.32	0.5% / 5kg maximum	$36.60 maximum	Used to bleach adhesive if colour is a problem.
Calcium stearate	Use when necessary	$8.98	0.2% / 2kg maximum	$17.96 maximum	Used to improve flow of wet adhesive.
Magnesium sulphate	Use when necessary	$5.32	5.0% / 50kg max	$266.0 maximum	Used to make paste more flexible in use.

Source: (Graffham and Dziedzoave 1998)

The level of investment required to exploit this opportunity will depend on the approach adopted for production of the basic cassava chips. If a field based approach is taken each farmer will require a capital investment of approximately US$120 to cover the cost of a manual chipper, plastic sheet and 15 bamboo drying trays. Farmers would normally operate in groups of six so the capital investment per group would be US$720. If a factory-based approach is adopted US$700 will be required for each mechanical chipper. Artificial drying will increase costs by around US$10,000 depending on the design and origin of the drying unit. To prepare cassava flour for industrial use approximately US$3,000 is required to purchase a suitable hammer mill and screening equipment with stainless steel screens covering the range from 1mm to 250µm. To prepare premixed glue powders an industrial mixer is required at a cost of US$8,000, alternatively using a cement mixer fitted with plastic shields to reduce dust could reduce costs. However, this is not a very satisfactory alternative and will increase hazards from chemical dusts in the factory environment.

The most likely economic bottlenecks affecting this opportunity are access to capital for processing equipment, and potential fluctuations in raw material prices and availability. Although cassava flour will be locally sourced, most of the chemicals required for SBA production are likely to be imported and thus subject to supply problems, changes in market price and currency devaluation.

The production of cassava flour for industrial uses offers another attractive opportunity for cassava farmers who are willing to process cassava into high quality cassava chips. However, to realise this opportunity farmers will need financial and technical support to prepare chips and access to the market. This is likely to be provided by the manufacturer of the SBAs and glue extenders. These manufacturers need to be willing to provide the necessary financial and technical support as well as providing some form of infrastructure to maintain quality and provide a mechanism for transfer of chips from the field to the factory. The experiences of T&CG (Ghana) in the area of chips for livestock feed could prove invaluable in this case (see Chapter VII). It is evident from experience in Ghana that quality is an important issue for users of adhesives and glue extenders. It is therefore vitally important that the adhesive manufacturer meets the user's specifications at a competitive price. If these specifications are met users will favour the local product because of the large cost savings made (typically 65-75%).

Locally produced SBAs based on cassava flour currently account for 45% of the market for paperboard adhesives. If manufacturers took more care over milling and screening of their products, and improved their understanding of the formulation of these products they could easily take over the entire market. The SBAs are essentially quite simple products and the necessary improvements are straightforward and could be achieved at low cost. However, many operators lack the technical knowledge to improve the quality of their products and have no access to external support.

In a conventional plywood process, synthetic adhesive contributes US$1.85-US$2.0 per sheet. Conventional glue extenders (maize starch & wheat flour) reduce this cost to US$1.38-US$1.54 (inclusive of cost of extender) depending on the cost and amount of extender used (Graffham & Dziedzoave 1998). If high quality cassava flour at a cost of US$65/tonne is used in place of wheat flour at a level of 25kg of flour per 50kg of adhesive the cost of adhesive and extender would fall to US$1.32-US$1.40 per sheet. However, experience in the Philippines showed that an extender consisting of cassava starch mixed with sodium hydroxide, calcium hypochlorite and filler allowed the percentage of resin solids to be reduced from 45% down to 22% without loss of bond strength(Fidel et al. 1992). This formulation was able to reduce adhesive costs by more than 50%.

In 1998 trials with cassava flour, prepared at village level, from either peeled or unpeeled roots and screened to 250um using steel mesh have been successful. These trials were carried out independently by two plywood factories in Kumasi and yielded comparable results.

It was found that unpeeled root flour was not suitable for extending plywood glue; as it increased the percentage of reject boards from 1% to 70%!! This was due to poor bonding resulting from high fibre and bark content (seen as non bonding blisters on the board surface).

In contrast it was found that peeled root flour could be used to replace 50-60% of wheat flour in the glue mix without loss of dry or wet bond (cold water soak) strength. When cassava flour was used at a substitution level of 50% plywood production costs were reduced by 35%.

Industry representatives are very interested in this work. They are now interested in trials using flour based versions of the Philippines type product.

Plywood glue extenders offer an excellent opportunity for cassava flour, with a relatively large market of more than 2,300 tonnes per annum in Ghana. 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). However, plywood manufacturers have been upset by the poor quality of locally produced products in the past. To exploit this opportunity manufacturers of cassava flour need to provide high quality on a consistent basis to build up the confidence of potential users of the product.

Case Study: Brazil

Olivier Vilpoux and Marco Tulio Ospina

Cassava starch production in Latin America is located mainly in Southern Brazil. There are some small plants in Colombia, Bolivia, Argentina and Central America, but their production is minimal in comparison to Brazil. Lorenz, the largest Brazilian cassava starch production company, also owns part of a Venezuelan plant, and has made joint ventures with three plants in Paraguay, one with a daily root processing capacity of 400 tons and two with a capacity of 200 tons.

In 1997, Brazil's 80 production plants produced 300,000 tons of cassava starch. Most of these plants are located in the States of Paraná, São Paulo, Mato Grosso do Sul. Of lesser importance are the plants in Santa Catarina. Five or six small plants are established in other States, but their production is less than 3 or 4% of the national production. In total there are around 60 cassava starch companies in Brazil, many of them operating several plants.

Most companies produce native cassava starch. However, in the past 5 years, the number of firms producing modified starches has increased and production at the end of 1997 represents around 30% of total cassava starch production. Modified starches are used primarily by the paper and textile industries (cationic and acid starches). Other modified starches include dextrin, maltodextrin and pregelatinized starches. In late 1997, a cassava starch firm called INDEMIL diversified its production by producing glucose syrup using an acid transformation. It's syrup production capacity of 80 tons a day. In 1998 this company increased its hydrolysis production using an enzymatic process. As more and more cassava starch firms penetrate into traditional cornstarch markets diversification within the cassava industry is inevitable as cassava starch firms compete with multinational companies. The following section will examine the characteristics of cassava starch production, focusing on the main opportunities for competition in the starch market and the problems that the industry must resolve to realize these opportunities.

Brazil is a large consumer of starch, with an increasing demand for starch as production of starch using products continues to grow. This market potential is matched by the potential to substantially increase cassava production owing to untapped production potential that exists in many agricultural and industrial areas of the country.

One of the most important features of cassava starch within the starch market is its agricultural production potential. Three factors contribute to Brazils potential to increase cassava production.

Good productivity: Between 1986 and 1998, the Brazilian cassava yields remained at around 13 tons per hectare. National yields however do not reflect the situation in Southern Brazil where some farmers produce up to 70 tons per hectare from 2 year-old cassava. Farmers in Southern Brazil, mostly of European origin, use modern production technology to achieve yields that are higher than the national average (Table III-8) and are in fact among the highest yields in the world. In comparison, cassava yields in Thailand are only 14 tons per hectare from one-year old root.

High starch content: the average starch content in the cassava varieties cultivated in the State of São Paulo (Fiber, Branca de Santa Catarina, IAC 12, and Mico) were never below 30%, and were on average 33% annually (Sarmento 1997). In comparison, the starch content in cassava from Thailand is around 26%.

Table III-8: Agricultural profile of the main cassava producing Regions in Southern Brazil

Regions	Cassava Averages: Area per farmer (ha)	Cassava Averages: Yield: 10 to 12 months mt/ha	Cassava Averages: Yield: 16 to 18 months mt/ha	Main agricultural activities of the Region
North-western Paraná	30 to 50	19.5	33.6	Cattle and cassava
Central Paraná	5 to 10	16.7	22.7	Cattle, cassava & corn
Western Paraná	2 to 5	25.1	42.8	Soybean, corn & cassava
Southern Mato Grosso do Sul	5 to 15	18.4	30.1	Cattle and cassava
South-western São Paulo	5 to 15	17.6	41.3	Corn, sugar cane & soybean

Source: (Vilpoux 1997).

Availability of large areas: small farmers on small land areas typically cultivate cassava. For a starch company, this means having to coordinate raw material supplies from a large number of suppliers. Cultivation on large land areas allows starch companies to reduce the number of suppliers and possibly make contracts to better co-ordinate raw material supplies. In Brazil, this situation already exists. Many farmers currently cultivate more than 1,000 hectares of cassava and land is still available for further cultivation and growth in the number of large farmers in the future.

The production process for making starch from cassava is very similar to that of making starch from potato or cereal. In fact, the production facilities needed to make cassava starch are simpler because cassava is a purer starch source than potato or cereals[6]. A cassava starch industry has excellent potential when compared with other cassava product industries for a number of reasons. Not only is there great agricultural potential but there is also the presence of large companies with access to excellent starch production technologies. The installation of a cassava starch plant in Brazil, with a capacity of 200 to 400 tons of root per day, costs between 1.5 and 2.5 millions dollars. The largest plants, with a capacity of 600 tons per day producing modified starches, can cost more than 10 million dollars. The sales of an average Brazilian cassava starch company are between 2 and 5 million dollars a year. Some of them reach 20 million and the Lorenz is said to have had sales of US$ 100 millions in 1997, with 35% coming from exports (Venda de Sao Geraldo aquece a disputa pelo pao de queijo 1998c). Lorenz specializes in modified starches, such as cationic, pregelatinized and acid modified starches, maltodextrin and dextrins.

[6] Cassava contains lower protein and fat percentages than potato and cereals used for starch production.

Between 1994 and 1996 many cassava starch firms increased their production capacity. In 1997, the four largest Brazilian companies produced more than 20,000 tons of cassava starch each. Three of the four companies distributed production across several plants. The largest companies continue to modernize, gaining in efficiency and in economies of scale allowing them to compete more effectively with the modified cornstarch industries. These companies, aware of this evolution, are in turn developing an interest in cassava starch production. National Starch joined one of the eight largest Brazilian cassava starch companies, Halotek Fadel, and CPC is looking for new partnerships. In May of 1998, Mitsui established a joint venture with Lorenz, the largest Brazilian cassava starch Company. This joint venture will allow a faster development of Lorenz, mainly in the Asiatic and North American markets.

A large number of companies are increasing the period of operation because of the need for a stable supply, rationalization of productive assets, better use of production capacity and a decrease in production costs. In the last three years, the annual period of operation significantly increased. Companies, located in the States of Paraná, Mato Grosso do Sul and São Paulo now operate 10 to 12 months a year.

In Southern Brazil, cassava is gradually changing its status from a seasonal crop to a year round crop. The increase in production period influences the extraction rates. From May to August, a ton of cassava typically produces 280 to 300 kg of starch. This drops to 200 - 240 kg of starch from December to February. Brazilian cassava starch companies that operate year round obtain average rates of extraction of 25 to 27%, based on root weight. In 1997/98, INDEMIL reached an annual average extraction rate of 30%, which is the best industrial productivity in the world for cassava. This company processed 140,000 tons of cassava in 1997 (two-thirds for starch and one third for “farinha”). These quantities prove that large production plants in Brazil are possible and are comparable to those already in Thailand. INDEMIL has plans to process between 170,000 and 200,000 tons of cassava in 1998 and to build another unit with a capacity of 1,000 tons of root per day.

The starch industry produces hundreds of products that are used in food and non-food markets of many different sizes. Starch demand can be classified in four main industries: food, paper, chemical and textile. Other industries, that use starch but in smaller quantities include the oil industry, construction industry, etc. (Leygue 1994). In 1998, starch sales in Brazil totalled 1 million tons, 70% produced from corn, and 30% produced from cassava[7]. Cassava starch is not imported into Brazil and exports do not exceed 20,000 to 30,000 tons. Cornstarch is imported into and exported from Brazil mainly by CPC International, but in small quantities. The Dutch company AVEBE also imports potato starch to a small degree. The starch market can be divided into three types; sugars, natives and modified starches, each one with a different potential for the use of cassava (Table III-9).

[7] For more information on the development of the Brazilian starch market see Phase 1 Report (Henry, Westby, and Collinson 1998).

In 1998, cassava starch competed with cornstarch in almost every market. In some markets, cassava starch exhibits clear advantages and corn companies are losing their position. The main markets for cassava starch are in delicatessens that use native starch and paper and textile industries that use modified starches. Until the early nineties, modified cornstarches dominated the paper and textile industries. Because of the superior properties modified cassava starches possess it now has a large market share in these two industries. The largest companies producing modified cassava starch for textile and paper markets are National Starch, a North American multinational, Lorenz, Halotek Fadel and INPAL. Other companies that are expanding include MCR and INDEMIL.

Table III-9: Market potentiality for cassava starch production in Brazil

Product	% Starch production	Main uses	Cassava starch opportunities	Comment
Native starches	42.8%	All industries	High	Price competition. Better for specific uses, when transparency, viscosity and water retention are important.
Sugars	47.2%	Beer	Low	Scale economies, with price war between CPC and Cargill. Price between US$ 220 and 250, lower than for natural starch.
		Food	Medium	Market division between CPC and Cargill, but existence of market niches. Price competition. Recent entrance of glucose units from cassava and one from rice.
Modified starches	9.4%	Paper	High	Better than cornstarch because of higher transparency.
		Textile	High	Better than cornstarch because of higher transparency.
		Food	High	Small uses but should increase in the future.

In spite of its potential a cassava starch industry faces a number of factors that limit its development.

Low level of mechanization in cassava cultivation: a comparison of production costs between cassava and corn reveals a different distribution of main cost items (Table III-10). The comparison indicates a higher use of additional technology such as inputs and automated activities in corn production relative to cassava production. If mechanization were to increase in cassava cultivation, lower labour costs could significantly reduce cassava root price and allow economies of scale for cassava farmers.

Market concentration: 2 companies in Brazil produce 700,000 tons of cornstarch. In comparison, the cassava industry is made up of more than 60 firms. The sheer size of these two corn companies allows them greater opportunity to invest in product research, reach major customers and reduce production costs. All of which is more difficult for the smaller firms in the cassava starch industry.

Table III-10: Breakdown of the main cassava and corn production costs (One year-old cassava with 20 -25 t/ha productivity):

	Corn		Cassava	
	US$ (1997)	%	US$ (1997)	%
Mechanized activities	80.08	35.8	85.36	18.4
Input	223.86	61.2	34.61	7.4
Labour force	62.18	17.0	345.02	74.2
Total	366.12	100.00	465.00	100.00

Source: Vilpoux, 1998.

Low education level: Large cornstarch companies typically employ specialists for every kind of job and professionals with good schooling. In contrast, in most cassava-based firms the owners manage the company and make all the important decisions. In most cases, the owner may not have had the opportunity of higher education, which may negatively impact the firm's growth opportunities. Another problem for smaller firms is the absence of technical sellers of starch, making it difficult to sell to large firms. As a result, cassava starch sales focus on a few traditional markets without expanding to new territory.

Lack of information: As a result of relatively low education levels among managers and the small size of cassava based starch firms it is very difficult to access market and production technology information. The consequences of this are difficulties in accessing new markets and technologies, price instability, and problems caused by not recognizing new directions in future production.

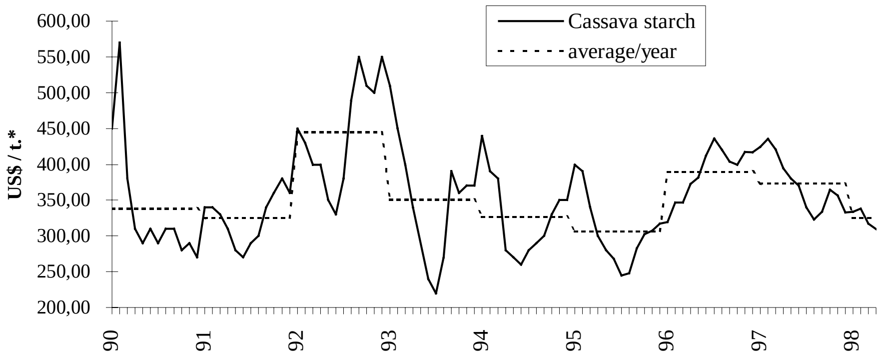

Figure III-2:Nominal cassava root prices (US$ FOB industry), in the North-western State of Paraná between January 1979 and May 1998
(Source:(FAXJOURNAL 1995)

Price fluctuations: cassava prices are subject to great seasonal variations. They typically reach a minimum price during the main harvest period (between May and August) and increase again by the end of the year (Figure III-2). Most agricultural raw materials are subject to seasonal variations in prices, both nationally and internationally. Frequently it is because of climatic and political factors. In Brazil, cassava starch competes directly with cornstarch. A comparison of raw material prices of both starches provides a good illustration of price fluctuations of cassava and cornstarch. In spite of great variations in corn price, instability of cassava prices is a lot higher (Figure III-3).

Because bottlenecks do exist, action is required to fully develop the cassava starch industry potential in Brazil. First is the distribution of information. For example, there is a need to obtain and diffuse market information such as price statistics for cassava and cassava starch within Brazil and around the world, as well as, the prices of main competing products. Information should also be obtained and diffused on consumption statistics of starch within Brazil and around the world. The main markets for cassava starch should be identified as well as the type of product in demand and in what quantities.

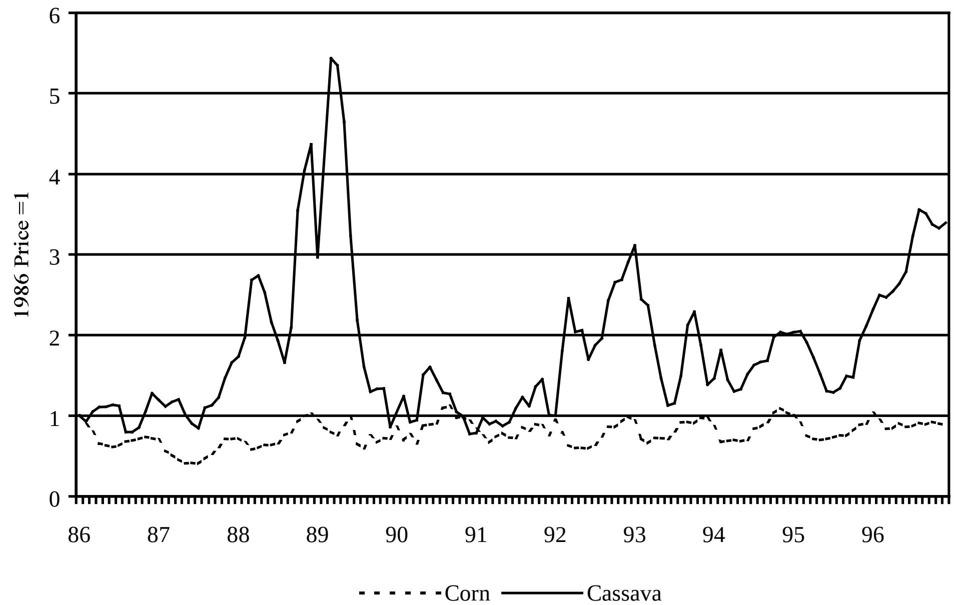

Figure III-3: Index of cassava and corn prices (1986 = 1)
Source: (Vilpoux 1997)

Technical information should be disseminated about new techniques for producing different types of starches, e.g., native starch, modified starch and hydrolyzed starch. Specialists should be educated. Managers should be educated about the different properties and uses of starches derived from different raw materials and through different processing techniques. Since many cassava-starch companies lack technical sales teams technical sellers need to be educated. To make the perfect match to product properties they need to acquire a working knowledge of their customers' starch needs.

The main area requiring attention is the modernization of cassava production through the development of new cassava varieties, mechanized harvesting, and development improved cultivation techniques machines. The raw material costs of cassava root represents between 50 to 60% of all costs within the cassava starch industry. This includes production costs and value-added taxes and explains the importance of reducing cassava root costs. Other costs in the starch industry are wages and value-added taxes, each representing 13% of all costs. The remaining costs include electricity at 4%, packing at 3%, and repairing and wood at 2% each, (Vilpoux 1997).

Modernizing of cassava production should help to stabilize prices and supplies. Today, many processing companies are regulating supply and prices by vertically integrating with cassava producers. It is argued that improved cooperation between companies and farmers, fixing minimum prices and planting and harvesting periods, would be more efficient than vertical integration (Vilpoux 1997).

It is also argued the price of final starch based products could be reduced by improving the starch extraction rate. For example, it is currently possible to achieve an extraction rate of 90% root starch with an end product of 12% humidity and 3.5 % other components and productivity in commercial starch of 35% of the total weight of the root. At this rate, processing could improve significantly from its current rate of 25 - 26% in Brazil and Thailand.

These needed improvements can be facilitated by governmental institutions, such as research centers and universities, IAC (São Paulo State), EPAGRI (Santa Catarina State) and IAPAR (Paraná State) for agronomic researches, and CERAT/UNESP (São Paulo State) for technology and market analysis. Nevertheless, even without scientific help, the cassava starch industry can and will continue to modernize and resolve these problems. The advantage of government intervention is that it could accelerate the modernization process and allow smaller companies to access the evolution. Analyzing future trends within the industry makes it possible to focus on a few important points:

Increase of industry concentration: Industry concentration has been increasing in recent years and should continue to increase in the future. The concentration ratio or percentage of national production of the four largest cassava starch producers was 27% in 1995 and has risen to 35% in 1997. The Concentration Ratio of the eight largest cassava starch companies has grown from 44 to 55% over the same time period (Vilpoux 1998). Although production at the largest cassava starch companies in Brazil continues to increase it is still lower than the average in Thailand, which is 30,000 ton of starch per year. Multinationals, like CPC International and National Starch, continue to show interest in cassava starch production in Brazil. National Starch, for example, is involved in a joint venture with a Brazilian company. Lorenz also recently made a commercialization agreement with the Japanese Mitsui. Other European multinationals, as CERESTAR, Roquette frères and AVEBE continue to study the possibilities of starting production units in Brazil. As the Brazilian cassava starch industry continues to concentrate, many existing companies could be closed within the next few years.

Modernization of cultivation: cassava producers are using more and more herbicides, allowing a decrease in cassava production costs. The harvest, which is mainly done manually and which represents the main production cost, is becoming more and more mechanized, allowing economies of scale and cost reductions to take place. In future years, more harvesting technologies will continue to become available.

Modernization of industrial process: extraction rates are increasing very fast, allowing better productivity. In 1993 the average annual extraction rate was 25%, in 1998 this same average is about 26-27%, with one company reaching 30%. In the meanwhile, production time continues to increase toward all year production and full capacity.

Modernization of cultivation and processing should reduce costs and make cassava starch more competitive with cornstarch. Table III-11 illustrates, the competitive situation of the Brazilian cassava starch industry in relation to competitors in Europe. Only potato has a better starch productivity per hectare, but a shorter processing time, which handicap the production and increase total costs.

Table III-11: Comparison of starch productivity for different kinds of cultures

Culture	Productivity (t / ha)	Starch extraction (%)	Starch productivity (t/ha)	Operation time months per year
Corn (Europe)	7.0	63	4.41	12
Corn (Brazil)	3.2	63	2.02	12
Wheat (Europe)	5.6	55	3.08	12
Potato (Europe)	35.8	23	8.23	5 - 6
Cassava (Brazil)	25.1(1)	30(2)	7.53	12

Source: (Leygue 1994) and IEA, 1994.

(1) Average productivity of Western Paraná for 1 year-old cassava;
(2) Productivity obtained by INDEMIL.

A cassava root price of US$ 35.00 (possible to reach with the adoption of new technologies in big areas and an extraction rate of 30%), allows the sale of starch at a price at around US$ 250.00. This is competitive with cornstarch prices in the United States and lower than starch prices in other Latin American countries. Such a price would allow an expansion of cassava starch in Brazil and exportation of product to other countries, mainly in South America but also in the United States and Europe.

This work has focused on the potential of cassava as a cheap source of starch. Its advantages are relatively high yields of between 20 and 25 tons per hectare and good extraction rates of over 30% starch to total root weight. Mechanization will allow further reductions of root crop prices and will stimulate increased acreage and supply to starch firms. Cassava planting has already been mechanized but the most complicated part is harvesting. In 1998 it was possible to find farmers cultivating more than 1,000 hectares of cassava. However, yields are relatively low because of the large quantity of labor required. Yields should increase in the near future.

A factor limiting the expansion of the cassava industry is the great variation in raw material supply that influences the price stability of cassava and its end products. In Brazil, in spite of this instability, cassava starch prices remain competitive in comparison to corn, with an average price of US$ 350.00 from January 1990 to December 1997. At present, the largest companies are attempting to stabilize production and guarantee farmers a minimum price of US$ 36.00 to stimulate cassava production. These companies are also regulating the supply with their own production of cassava. In 1996, in the main producing regions, cassava starch companies obtain on average between 20 to 30% of their total cassava needs from their own production (Vilpoux 1997). The biggest firm however, which utilized 140,000 tons of root in 1997 (for starch and "farinha"), does not produce cassava anymore, preferring to buy its raw material supplies with and without contracts.

Modernization, growth, and the development of new technologies will strengthen the industry in the near future. Multinational companies such as

National Starch and CPC International are already very interested in the evolution of cassava starch production. International investments in cassava could allow Brazil to reach similar levels of development to that of Thailand and supply Latin American markets. The competitive advantage of Brazil is its high cassava productivity and the root starch content.

The installation of large cassava starch plants in other Latin American countries, such as Colombia, Bolivia, Venezuela and Paraguay are possible and some already exist in Venezuela and Paraguay. Industrial and agricultural requirements are similar to those discussed for Brazil. The bottleneck for the installation of these production plants is the distance from main consumption markets. Starch is a product that is consumed by other industries and its consumption increases with overall economic development. In Latin American countries, these consumption regions are located in Southern Brazil, Argentina and Chile. Since cassava is easily grown in only the first region, Brazil has the opportunity to be the main cassava starch producer in South America.

Case Study: Thailand

Boonjit Titapiwatanakun

In Thailand, the cassava starch industry is export oriented. The industry is rapidly shifting from the export of native starch to the export of modified starches. According to the traders, modified starch is broadly classified into 2 major categories physically modified starch and chemically modified starch. Monosodium glutamate (MSG), derived from native starch and a major user of native starch in Thailand, is not treated as a modified starch.

The Thai modified starch industry began in 1984. By 1998, there were 49 cassava starch factories, 11 making modified starch or equipped with modified starch facilities. Most are joint ventures with developed countries. Of the 49 factories, 26 factories are located in the North-eastern region. Nakhon Rachatsima and Korat have 11 factories. Of the remaining factories, 20 are located in the Central region (Eastern seaboard) and 6 are located in the Northern region. The estimated annual capacity is 1.8 million tons of native starch, of which 300 to 500 thousand tons are further processed into modified starch.

The native and modified cassava starch industries are export-oriented. From 1993 to 1997, total export volumes of native starch increased from 460 thousand tons to 872 thousand tons. The average export price increased from 5,070 baht/ton to 7,140 baht/ton (US$200 to US$275). Among the 10 major importing countries, Taiwan is the largest importer. The quantity exported to Taiwan increased from 180 thousand tons (39 percent of the total exports) in 1993 to 313 thousand tons (36 percent) in 1997. Japan is the second largest importer. The quantity exported to Japan, however, has been decreasing from 114 thousand tons in 1993 to 76 thousand tons in 1997. From 1994 to 1997, Indonesia imported more than 150 thousand tons/per year. This contributed significantly to Thailand's increased native starch exports (Table III-12).

Exports of modified starch also increased during the 1993-1997 period. In 1993 modified starch exports were 195 thousand tons. By 1997 modified starch exports were 264 thousand tons. Among the 10 major importing countries, Japan imported more than 55 percent of Thailand's modified starch exports. The quantity exported to the Netherlands and Indonesia also increased, especially to Indonesia. The quantities to the other 7 major importing countries have been fluctuating. The markets for Thailand's native starch and modified starch are rather concentrated and limited (Table III-13). Seven of the ten major importing countries of modified starch are also the major importers of Thai native starch.

Table III-12: Quantity and value of Thai native starch exported to 10 major importing countries, 1993-1997
(Unit: Quantity (Q) = 1,000 tons, Value = million bath, Price = baht per ton)

Country	1993			1994			1995			1996			1997		
	Q	V	Price	Q	V	Price	Q	V	Price	Q	V	Price	Q	V	Price
Taiwan	180.7	854	4,725	248.3	1,341	5,399	200.5	1,502	7,493	275.0	1,788	6,503	313.2	2,010	6,418
Japan	113.5	574	5,056	101.4	652	6,429	55.8	475	8,502	76.4	508	6,658	76.4	501	6,550
Hong Kong	30.0	181	6,038	33.9	205	6,035	36.4	311	8,546	42.8	307	7,165	47.9	334	6,982
Malaysia	29.6	148	4,987	41.1	240	5,840	49.7	375	7,542	62.5	407	6,513	80.4	513	6,378
Singapore	35.7	145	4,061	39.8	210	5,276	42.4	333	7,859	33.1	215	6,485	45.9	281	6,111
USA	17.7	118	6,653	24.9	161	6,475	20.1	206	10,250	33.6	294	8,730	23.4	233	9,973
China People's	12.3	92	7,423	20.0	141	7,045	29.2	401	13,732	34.9	530	15,171	43.8	671	15,332
Australia	9.4	44	4,670	9.5	59	6,245	8.2	71	8,726	7.9	57	7,223	8.8	69	7,836
South Africa	3.1	15	4,903	7.8	60	7,743	8.0	49	6,169	7.6	56	7,451	8.0	64	8,049
Indonesia	0.0	0	10,032	186.4	1,058	5,677	150.2	1,009	6,715	1.2	13	10,413	173.0	1,167	6,744
Others	28.0	162	5,798	34.7	192	5,521	28.8	253	8,774	55.7	405	7,279	51.4	383	7,449
Total	460.2	2,333	5,069	747.9	4,319	5,775	629.3	4,985	7,922	630.8	4,581	7,262	872.3	6,227	7,138

Source: Customs Department

Table III-13: Quantity and value of Thai modified starch exported to 10 major importing countries, 1993-1997
(Unit: Quantity (Q) = 1,000 tons, Value = million bath, Price = baht per ton)

Country	1993			1994			1995			1996			1997		
	Q	V	Price	Q	V	Price	Q	V	Price	Q	V	Price	Q	V	Price
Japan	129.2	1,493	11,558	119.7	1,415	11,828	143.7	1,796	12,497	145.3	1,922	13,231	150.5	2,180	14,487
USA	29.6	222	7,488	15.1	214	14,150	10.6	207	19,426	18.6	321	17,291	11.5	225	19,505
Netherlands	8.8	98	11,143	9.2	101	11,036	10.1	141	14,017	26.8	324	12,104	17.0	237	13,989
Malaysia	5.7	93	16,443	7.0	105	14,950	10.3	146	14,263	7.4	120	16,176	9.6	180	18,630
Taiwan	6.2	79	12,677	6.1	73	11,926	3.9	51	13,215	4.7	61	12,890	4.8	74	15,418
Indonesia	4.2	52	12,496	7.1	90	12,732	14.3	213	14,860	23.3	358	15,330	37.8	662	17,495
Philippines	2.6	34	12,996	4.1	49	12,187	5.6	72	12,844	6.2	86	13,866	6.3	97	15,284
New Zealand	1.7	33	19,242	1.0	18	18,376	1.2	26	21,533	1.3	28	21,230	1.4	31	22,154
Hong Kong	1.8	22	12,395	1.9	23	12,386	3.0	43	14,341	3.6	54	15,055	4.6	76	16,450
Australia	1.0	19	19,121	1.2	18	16,013	1.6	27	17,243	2.0	34	17,000	3.1	49	15,899
Others	4.4	49	11,072	5.8	80	13,728	10.9	155	14,276	21.9	276	12,602	17.4	276	15,866
Total	195.1	2,193	11,239	178.0	2,187	12,287	215.0	2,876	13,375	261.1	3,584	13,724	264.1	4,086	15,475

Source: Customs Department

In the 1988-1997 period, the export price of native starch (f.o.b. Bangkok) fluctuated between 4,398 baht/ton in 1989 and 7,922 baht/ton in 1995 (US$173 to US$308). A similar pattern was experienced in the price of hard pellets. During the same period, the export price of modified starch increased every year from 4,683 baht/ton to 8,736 baht/ton to 15,475 baht/ton (US$185, US$348, US$611, respectively). The one exception was in 1992-1993 when a slight decrease was observed. On average (1988-1997), the modified starch price was about 2 times higher than native starch, and 4 times that of hard pellets (Figure III-4).

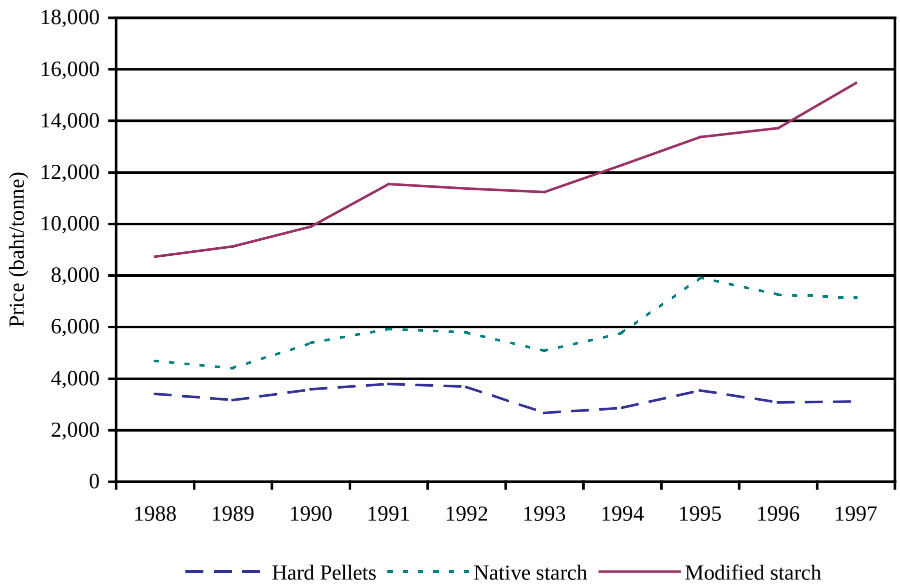

Figure III-4: Export price of cassava hard pellets, native starch and modified starch

At least two favourable physical factors contribute to these growth trends. One factor is the increased accessibility to improved infrastructure. This makes it possible to set up factories in more remote areas where land prices are low and pollution problems can be addressed with low cost technology. A second factor is the availability of domestic mechanical engineer firms, equipped with improved mechanical know-how and the ability to duplicate new imported technologies, to expand factory capacity at a comparatively lower cost. As a result, native starch production increased while the number of factories remained almost constant. In fact, Thai firms have set-up native starch factories for firms in Indonesia and China.

Two factors limiting the expansion of native starch factories are land prices and pollution. Town expansion, urbanisation and the boom in real-estate (housing and recreation) in most of the cassava growing regions are the main causes of inflated land prices and complaints about the pollution produced by the native starch factories. The development of modified starch is slowed by the lack of commercially viable modern domestic technologies for modified starch production. Thai research on modified starch technologies and utilisation exists, but the results of this research have not yet been tested and adopted. At present, most of the modified starches are produced using imported technologies provided through joint ventures.

An important economic factor that has contributed to the growth of the export market has been the comparatively lower trade barriers imposed on the imports of modified starch by the importing countries. Another economic factor that contributed to the growth of the export market has been the high costs of domestic modified starch in some developed countries, such as Japan. Therefore, the joint ventures with developed countries provided not only technology transfers to Thailand, but opened the export markets for Thai modified starch.

The bottleneck for export growth is the existing subsidy on corn and potato starch in the developed countries that are the major markets for modified starch. These subsidy policies also jeopardise the export growth of Thai modified starch in new markets, because Thai modified starch has to compete with the subsidised low-price modified starch exported from the developed countries.

In the domestic market, the initiation of domestic modified starch production opened up the possibility of import substitution in Thailand. This was particularly true for those modified starches for industry usage e.g. paper and packaging industry. In addition, the expansion of the Thai agro-industry has opened the potential market for modified starch in both food and non-food sectors. In general, one can envisage that there is a sizeable domestic potential demand for modified starch, which has yet to be penetrated through an active technical sale promotion.

The limitation to domestic market expansion is that prospective industrial users lack knowledge of the availability of modified starch. In addition, prospective industrial users lack confidence in using the domestically produced modified starch as a substitute for imported modified starch in their production line. This is owing to the fact that the input cost of modified starch constitutes only a small proportion of the final cost of most industrial goods. Therefore, the saving realised from switching from imported modified starch to the locally made starch is not sufficient to compensate the risk of having problems on the production process.

Native starch factories are the stakeholders of the development of modified starch. The recorded numbers of factories increased from 50 in 1970 to 146 factories in 1978. In 1989 only 47 factories were registered as members of the Thai Tapioca Flour Industries Trade Association TTFITA. The estimated annual capacity was 1.3 million tons of native starch. By 1995 the number of factories registered with the TTFITA increased to 54 factories with an estimated capacity of 1.4 million tons per year. Three years later the number of registered factories was 49 with an estimated annual capacity of 1.8 million tons. During this time span the location of native starch factories had shifted from the Central region (Eastern seaboard) to the north-eastern region, now the major cassava growing area (Table III-14).

Table III-14: Cassava or native starch factories by region and total estimated annual capacity in selected years.

Year	Number of factories					Annual capacity 1,000 ton of starch
	North	Northeast	Central	South	Total	
1970		2	48		50	NA
1973	1	3	124		128	NA
1978	1	12	132	1	146	NA
1989	4	23	20		47	1,265
1990	4	22	19		45	1,353
1992	3	23	20		46	1,265
1995	3	28	23		54	1,400
1998	3	26	20		49	1,750

Note: Annual capacity is computed by using the estimated daily capacity multiplier with the annual average operating days.
Source: (1) 1970 and 1978 from Ministry of Industry
(2) 1989 until 1998 from The Thai Tapioca Flour Industries Trade Association.

Native starch factories have improved and expanded their capacity and implemented both forward and backward integration. In setting up modified starch operations some factories exported their own products while others sought joint ventures with exporters and foreign firms. Still others rented out their premise to other firms for the production of modified starch. All factories played an active role in the development of native and modified starch and were involved in the development of government price intervention programs. These factories also participated in the dissemination of new improved varieties to cassava growers and initiated contract-farming systems between cassava growers and starch factories.

More than 80 percent of the total registered members of the Thai Tapioca Flour Industries Trade Association are also exporters of both native and modified starch. At the forefront of the Thai native and modified starch industry, exporters have access to market information on each importing country and can explore new market possibility for the starch industry. In most cases, exporters are the initial contact point for bringing foreign joint ventures into the modified starch industry.

The trader associations have explored new market opportunities through trade missions. These missions have been assisted by concerned government agencies. The trade associations and exporters have also been involved, to some extent, in the formulation of cassava policies and in setting up cassava research and development agendas, through their participation in ad hoc committees set-up by the government.

The Thai Tapioca Trade Association (TTTA) and the Thai Tapioca Flour Industries Trade Association (TTFITA) are the two most active private institutions involved in policy, research and development of native and modified starch. The close linkage between these two associations is due to the integration between the respective industries. These associations have, to a certain degree, determined the research and development agenda of the Thai Tapioca Development Institute Foundation (TTDIF).

The TTDIF was founded in 1992 with an endowed fund of 600 million baht, collected from the auction of EU export quota in 1991. The Foundation has six major activities: 1) promotion of research and development on selected new varieties of cassava, 2) carry out research and development on production structure, 3) addressing problems of tariff and trade barriers, 4) evaluation the efficiency of competitive exporters, 5) establishing information units within TTDIF that can assist the public and private sectors, and 6) carrying out activities with non-political charitable organisations that are beneficial to society. (The Thai Tapioca Development Institute 1998)

Examples of Foundation funded research include the reduction of cassava production cost by using high yielding varieties such as KU 50 and Rayong 90, marketing research and market news activities, technology development such as improving the efficiency of starch factories, new products with high value-added (bio-degradable products) and animal feed, information collecting and disseminating, and human resource development, such as overseas short training, seminar and exchange researcher programs.

There is a sizeable domestic potential for modified starch. The potential market for modified starch can be estimated by the domestic utilisation of native starch for producing selected modified starch. In 1995 native starch used for producing modified starch was estimated at 490 thousand tons. This increased to 512 thousand tons in 1997 of which 61 percent was used in producing modified starches (both physical and chemical); 25 percent was used in glucose/fructose syrup production; and 8 percent each used in producing sobital and high fructose. Total starch utilisation is expected to increase to 583 thousand tons by 2002. It should be noted that the estimation was carried out before the current financial crisis. The estimated native starch utilisation showed that sobital and other modified starch had relatively high growth rates that reflect increasing potential domestic demand for modified starch (Table III-15).

Table III-15: Estimated domestic utilisation of native starch for producing selected modified starch (1000 mt)

	1995	1997	2002	2007
Modified starch	300	310	337	365
Glucose / Fructose syrup	120	122	126	130
Sobital	30	40	80	158
High fructose	40	40	40	40
Total	490	512	583	693

Source: (Titapiwatanakun 1997)

The annual quantity exported of Thai modified starch increased every year since 1993 at an annual compound growth rate of 8 percent. Japan is by far, the largest market for Thai modified starch with an estimated annual growth rate of 4 percent quantity imported (1993-97). There is an increasing export market potential for Thai modified starch, especially for industrial use in Asian countries. Modified starch is mostly for industrial usage, where cassava modified starch has to compete with modified starch from corn and potato.

Based on the current growth rate of modified starch exports, modified starch exports from Thailand in 2002 could be 388 thousand tons. With the devaluation of Thai baht against the US dollar this export quantity could to be more.

The lesson learned from the development of modified starch industry in Thailand can be summarised as follows:

Size of export market: The scale of the Thai export market encouraged farmers to grow cassava rather than other cash crops. Those able to produce cassava with high starch content could sell roots for native starch process, while those producing roots of low starch content could sell roots for chips and pellets for animal feed.

A native starch industry: Development of a stable native starch industry provided the basic material for further processing into high value-added products and modified starches.

Free Markets: A relatively free market environment contributed to the development of both the native and modified starch industries.

Mature Base of Industries: Mature industries for native and modified starches, as well as, cassava products for animal feed allowed the industry, with the co-operation of government agencies, to organize, set up and institutionalize research and development in support of sustainable development within the industry.

The Thai success in export market validates a number of old adages: firstly one must recognize and seize opportunities when they arise, and secondly success begets success. A number of countries in the sixties and seventies would appear to have been positioned to export cassava products, but they never realizes the opportunity.

Conclusions

The case studies of domestic cassava starch markets provide a consistent picture that there is a potential, often time's unexploited market for cassava starch. Modified cassava starch is becoming increasingly important, but the predominate cassava starch is still native cassava starch. In general, domestic cassava starch is competitively priced to imported starches. The examples of Benin and Malawi, representative of many smaller cassava-producing countries, illustrate the problem of having a growing market for starch, which is unfortunately still very small. The current small size of the starch market in many countries discourages the development of "modern" starch factories. For example, the Malawi market can only use about twenty percent of what could be considered to be a "traditional" cassava starch plant and Benin only 3 percent. Even in Ghana, the market requirements are approximately what can be produced by one traditional cassava starch plant working 4 to 6 month a year.

The case studies of Thailand and Brazil illustrate that cassava starch can be competitive in the world market and in domestic markets. Thailand exports about a million tonnes of starch, about one third of which is modified. Thailand also uses about 800,000 tonnes of starch (native and modified) domestically. Brazil's domestic market is approximately 300,000 tonnes. About one third of Brazil's starch is produced from cassava.

Whether the domestic cassava starch industry is small or export based there are a number of barriers to its development. The most commonly identified barriers, noted in the case studies, are a lack of consistent supply of raw material, unfamiliarity with the potential uses of cassava starch, poor quality control over of the starch production, small scale of starch processing tends to limit production of modified starches and a concern about the cost of cassava.

A number of the case study countries felt that they could export cassava starch. However it must be recognized that their cassava starch production capacity, or proposed capacity, is less than 1 day of Thai cassava starch production. In addition, all countries, including Thailand, may encounter price support regimes in importing countries (especially developed countries) that are barriers to exports.

Chapter IV: Cassava Chips

Global Opportunities

Truman P. Phillips

The Europeans demonstrated that given the correct price regime, cassava in the form of chips or pellets is a very useful animal feed ingredient. They demonstrated that cassava, mixed with protein rich ingredients and given the EU price regime, was an economical replacement for imported grains, primarily maize. This same situation may exist for cassava producing countries. As illustrated in the following table there has been an increase in per capita maize imports from 1961 to 1995 (Table IV-1).

The greatest increase in maize imports has occurred for Latin America. Asia has also shown a marked increase in maize imports, although the average level of imports is about one-third that of Latin America. On a regional basis, the African countries have the lowest per capita import of maize. A partial explanation for these differences may be accounted for by the continental trends in urban growth and expanding livestock numbers.

Table IV-1: Per capita imports Maize (kg/year)

Region	1961	1970	1980	1990	1995
Africa	0.30	1.43	6.50	1.95	2.44
Asia	0.28	0.59	2.62	2.97	5.92
Latin America	0.35	1.97	17.33	10.44	18.79
Oceania	0.00	0.00	2.37	0.68	3.97

Source: (FAO 99).

The case for the growth in maize imports being related to the increase in livestock numbers is supported by an examination of the index of livestock numbers, particularly those for chickens, appears to exhibit a similar pattern to the import of maize Table IV-2. One might argue that the growth in the Latin American livestock index does not justify the large maize imports. But examination of the individual country data shows that a large portion of the growth has occurred in Brazil, a country that has developed one of the most intensive poultry industries in the world. Hence, increased imports to Brazil reflect growth in livestock numbers and an intensification of feeding practices.

Table IV-2: Index of selected livestock numbers (1961=100)

Region	Cattle 1995 Index	Pigs 1995 Index	Chickens 1995 Index
Africa	170	486	378
Asia	141	436	521
Latin America	203	144	512

Oceania	347	347	760

Source: (FAO 99).

Applying simple time trends to these FAO data, the use of cassava as an animal feed looks promising. One cannot, however, put as much faith in these trends as one could for the human food market. In particular, the European trend is not expected[8] to continue (Figure IV-1). Note that these figures are in *fresh root* equivalence not tonnes of cassava chips or pellets. The optimistic estimate is that the European market will stay at its present level, which is less than half the trend projection.

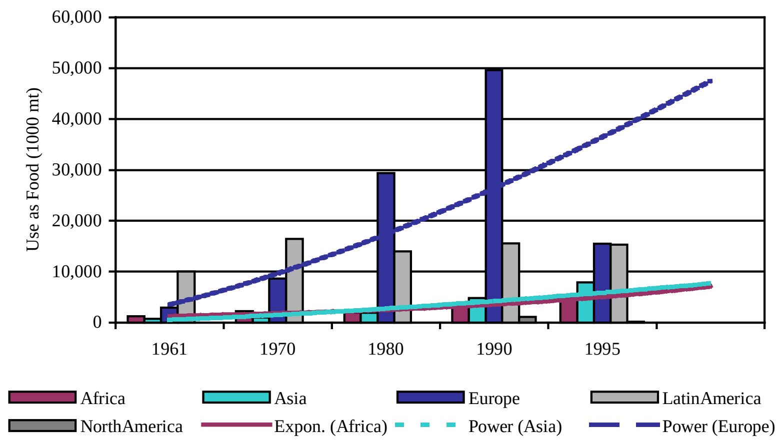

Figure IV-1: Regional trends in use of cassava as animal feed to 2005

One anticipates that the upward trends for Africa and Asia could be realised. The rather flat Latin American trend is unexpected. As shown above, livestock numbers are growing in Latin America, leading one to anticipate a somewhat similar pattern in the growth in the use of cassava as an animal feed. Brazil's highly developed and large poultry industry has existed for some time. Perhaps this explains why there is limited additional growth in the animal feed sector in Latin America.

Placing an upper limit on the EU imports of cassava, but accepting the other growth trends, the market for cassava as an animal feed might grow by 6 million tonnes reaching 50 million tonnes fresh root equivalence by 2005. This is a greater than FAO's estimate that 40 million tonnes of cassava will be used as an animal feed[9] (FAO 1997). Both the FAO report and this report agree that

> *Although the potential for further expansion as a substitute for grains is considerable, it remains largely unexploited and much would depend on*

[8] See Chapter VII for the European and Thai perspectives on the future European demand for cassava as an animal feed ingredient.

[9] The difference is largely explained by the assumption about the EU animal feed market. The FAO estimated that the EU demand for cassava could decrease by 6 million tonnes by 2005 while it was assumed for this study that the demand would remain constant.

the relationship between the prices of cassava vis-à-vis protein meals and feed grains. Furthermore, there would need to be an expansion of processing facilities in countries where supplies of cassava roots are abundant to meet any potential growth in domestic and export markets. (FAO 1997)

While there is some doubt about the future size of the global market for cassava as an animal feed, there is little doubt that this is a market that should be developed.

The great potential and growth of European demand for cassava as an animal feed ingredient is not going to continue because of changes in trade policies and domestic agricultural policies in Europe. Furthermore, global reductions in agricultural protectionism will further reduce the likelihood that other non-cassava producing country will begin to import cassava for animal feed.

On the other hand, global reductions in agricultural protectionism suggest that world prices will increase, thereby improving the competitive position of cassava domestically. In addition, many cassava-producing countries are expected to experience a growth in intensive livestock rearing. Intensive livestock production will undoubtedly place greater reliance on the use of compound animal feeds, which can include cassava as an ingredient. As an estimate of the import substitution opportunities for the use of cassava in animal feeds it is assumed cassava chips or pellets can replace 10 percent of maize imports at a ratio 2.5:1.

It can be seen from Table IV-3 that the market expansion opportunities for cassava as a substitute for maize is less than the import substitution opportunities for wheat flour imports. The average price of maize imports shows slightly less variability than the import price of wheat flour. This is probably because wheat and wheat flour imports cover a range of quality levels. Maize imports are probably of a more consistent quality. (Unfortunately data to confirm or refute this possibility are not readily available). The maize import price sets a target price for cassava chips and pellets. Given the assumption of a 2.5:1 ratio of cassava roots to maize, the target price for cassava roots plus processing ranges from $58.00 to $75.00 per tonne. Thus the target price for cassava whether used to replace wheat, wheat flour or maize is roughly the same. It is probable that the quality standards and processing cost are higher for cassava that substitutes for wheat and wheat flour than for cassava that substitute for maize.

Table IV-3: Cassava potential based on 10% maize replacements

Region	Cassava Potential (mt)	% of 1995 Production	Average Maize Import Price (US$/mt)
Africa	312,527	0.37%	$187.91
Asia	4,694,368	9.75%	$154.47
Latin America	1,997,771	6.15%	$145.68
Oceania	6,180	3.69%	$183.50

At the national level at least 13 countries appear to have the opportunity to expand the demand for cassava by more than 20 percent if they realise the potential for using cassava as an animal feed ingredient, Table IV-4. Potential exists in Latin America, but both Malaysia and China would appear to have an opportunity to create large cassava based animal feed industry. The FAO identifies Brazil, China and Nigeria as potentially the largest users of cassava as an animal feed by the year 2005 (FAO 1997). Interestingly Nigeria does not appear to be one of the large potential markets for using cassava as an animal feed in this study. This is because the analysis is based on import substitution opportunities and not directly on the growth potential of national livestock industries. Nigeria has basically banded the import of maize and wheat into the country; therefore a different type of analysis is needed to provide a more reliable analysis of the opportunities in Nigeria. This may also be true for other countries in the analysis.

Table IV-4: Cassava potential based on 10% maize replacement (National)

Country	Cassava Potential (mt)	% of 1995 Production	Average Maize Import Price (US$/mt)
Africa			
Malawi	58,750	30.92%	$238.30
Rwanda	33,500	22.33%	$156.72
Senegal	6,387	11.51%	$164.04
Zambia	21,202	4.08%	$226.35
Angola	41,250	1.72%	$151.52
Mozambique	51,250	1.42%	$190.24
Kenya	10,000	1.19%	$162.50
Burundi	3,650	0.73%	$136.99
Zimbabwe	566	0.38%	$310.24
Tanzania	20,250	0.34%	$148.15
Somalia	125	0.31%	$150.00
Cameroon	2,349	0.17%	$149.82
Niger	350	0.16%	$150.00
Benin	1,250	0.09%	$130.00
Togo	436	0.07%	$125.50
Ghana	2,500	0.04%	$210.00
Uganda	750	0.03%	$180.00
Sierra Leone	62	0.03%	$120.00
Congo, Dem R	5,375	0.03%	$186.05
Cote d'Ivoire	382	0.02%	$385.22
Chad	32	0.01%	$1,804.69
Gabon	7	0.00%	$2,821.43
Cent Afr Rep	3	0.00%	$76.92
Madagascar	8	0.00%	$882.35
Nigeria	2	0.00%	$250.00
Guinea-Bissau	0	0.00%	$0.00
Guinea	0	0.00%	$0.00
Eq Guinea	0	0.00%	$0.00

Country	Cassava Potential (mt)	% of 1995 Production	Average Maize Import Price (US$/mt)
Congo, Rep	0	0.00%	$0.00
Comoros	0	0.00%	$0.00
Liberia	0	0.00%	$0.00
Asia			
Malaysia	595,816	135.41%	$160.00
China	2,925,587	83.56%	$151.90
Sri Lanka	19,527	6.73%	$157.85
Philippines	52,006	2.66%	$183.57
Indonesia	242,298	1.57%	$159.01
Thailand	70,110	0.39%	$170.85
Viet Nam	6,500	0.29%	$215.38
Laos	125	0.18%	$260.00
India	2	0.00%	$545.45
Myanmar	0	0.00%	$0.00
Cambodia	0	0.00%	$0.00
Latin America			
Guatemala	43,563	273.09%	$143.35
Jamaica	44,643	255.88%	$152.54
El Salvador	48,663	147.98%	$147.34
Panama	41,326	130.78%	$157.66
Dominican Rp	168,750	123.34%	$118.52
Venezuela	264,380	88.35%	$136.69
Costa Rica	86,254	69.00%	$151.24
Peru	264,098	48.24%	$146.08
Cuba	60,750	24.30%	$135.80
Colombia	288,385	16.46%	$152.67
Nicaragua	8,095	15.72%	$97.46
Ecuador	4,587	6.06%	$940.48
Haiti	10,000	2.86%	$172.50
Fr Guiana	345	1.92%	$392.19
Brazil	327,333	1.29%	$138.10
Argentina	1,020	0.64%	$2,156.50
Bolivia	1,562	0.53%	$306.19
Paraguay	1,050	0.04%	$857.14
Guyana	0	0.00%	$0.00
Oceania			
Papua N Guin	5,000	4.39%	$180.00
Fiji	150	0.59%	$300.00
Tonga	0	0.00%	$0.00

It would seem that the animal feed markets in cassava producing countries are a promising growth market. The discouraging feature is that the market has only been growing by 1.3 percent a year (FAO 1997). As indicated in Figure IV-1, the fastest growth appears to be occurring in Southeast Asia (also refer to the Thai Case Study, Chapter VII). However, given the previously noted growth in livestock numbers (pigs 4.5% annually and chickens 7% annually) and importation of maize (greater than 15 percent a year), one would have expected a faster growth rate in the domestic use of cassava for animal feed.

The above analysis suggests that the domestic use of cassava as an animal feed should be a growth opportunity. This growth is partially dependent on a number of factors. One, a more intensive livestock industry that uses prepared animal feeds. Two, a feed compounding industry that is willing to use cassava. Three, a constant supply of competitively priced cassava coupled with a constant supply of protein rich feed ingredients and four, an infrastructure that links cassava producers to feed compounders.

Case Study: Zimbabwe

Andrew Graffham and Andrew Westby

Cassava is not widely grown in Zimbabwe at the present time. However, a feasibility study in Zimbabwe carried out by the Natural Resources Institute in collaboration with the Commonwealth Science Council during 1993 indicated considerable potential for cassava (Kleih 1994). Farmers expressed interest in cassava as a food security and possible commercial crop, on the basis that it is drought tolerant and could be grown on marginal lands with low levels of inputs. The study in Zimbabwe indicated that the marketing of dry cassava to the animal feed sector was the most attractive option in the short to medium term.

In 1993 three major feed millers expressed strong interest in cassava as a substitute for maize if cassava chips could be produced for less than the cost of maize at US$151 per tonne. These millers provided estimates of likely demand for dry chips (Table IV-5). Economic predictions indicated that farmers could grow cassava and prepare dry chips for sale at US$80 per tonne profitably if certain conditions could be met. Estimates were made on the basis of farmers achieving a yield of 15 tonnes of roots per hectare. If this figure was achieved farmers could produce cassava chips on farm (using simple equipment) for sale at US$80 per tonne. At this price the net income per farmer from 1 hectare of cassava would be US$181 or US$1.53 per labour day.

Table IV-5: Potential demand for cassava chips for livestock feed in Zimbabwe during 1993

Miller	Potential demand
Triangle Ltd	2,000 tonnes per annum
Agrifeeds	20,000 tonnes per annum
National Foods	10,000 - 40,000 tonnes per annum

Source: Kleih (1994).

In 1993 the potential for chip production looked positive and recommendations were made for a project to promote cassava production and processing with the intention of involving 1,000 farmers in the production of 500 hectares of cassava within 4 years. Given a yield of 15 tonnes of roots per hectare, 500 hectares would provide 7,500 tonnes of fresh roots or 2,777 tonnes of dry chips (conversion factor = 2.7).

However, in 1997 Triangle Ltd. indicated that the demand for cassava had fallen owing to macroeconomic problems affecting the livestock feed industry. Triangle revised their original estimate of 2,000 tonnes of dry chips per annum down to between 20 and 200 tonnes of dry chips per annum (Kleih 1998). The reduction in demand for cassava appeared to be related to changes in agricultural policy involving land redistribution, high inflation and generally poor economic performance. In spite of the less positive environment for cassava, cassava was still considered to have a potential for development because of large differences in price for cassava and maize.

The evaluation of processing options cassava chips included both field-based and centralized processing. Recommendations were made to promote a simple field-based technique on the basis of cost versus return-on-investment for the pilot project. The analysis did suggest that centralized processed might become an option in the future if a cassava based economy was established in Zimbabwe. The field-based option consists of chipping washed cassava roots with a manual chipper and then drying chips on cement drying floors.

One of the feed millers in Zimbabwe provided a specification for cassava chips for use in livestock feed (Table IV-6). It is interesting to note that no mention of cyanide or general chip quality is made; this indicates that feed millers in Zimbabwe are generally unfamiliar with cassava as a feed ingredient.

Table IV-6: Specification of cassava chips for livestock feed in Zimbabwe

Parameter	Percentage
Moisture (maximum)	12-14%
Starch (minimum)	70%
Total sand & ash (maximum)	2-5%
Crude Fibre (maximum)	4.0%
Protein (minimum)	2%
Aflatoxin (maximum)	<0.005 ppm

Source: (Kleih 1998)

This opportunity has been influenced by the existence of marginal land areas within 100km of major feed millers with reasonable road access, that are currently under- utilised. Farmers are keen to adopt a crop that is drought tolerant and can improve the economic returns from these lands.

The recommends of the evaluation project were that field-based processing of cassava be done in marginal areas of Zimbabwe, and that the chips be sold directly to livestock feed millers or used in feed formulations by farmers co-operative groups.

The likely physical bottlenecks that could hinder exploitation of this opportunity are as follows (Kleih 1994; Kleih 1998):

Biennial cropping system. Due to the long dry season in the marginal areas, cassava is likely to be a biennial crop in Zimbabwe with harvest taking place 18 months after planting. This will affect cash flow during the early stages of the project, and it also requires farmers to use staggered planting techniques to ensure a reliable supply of cassava.

Encroachment by wild and domestic animals. During the dry season unwanted grazing by wild and domestic animals is likely to be a serious problem thus introducing the need for goat proof fencing that increases costs and requires additional maintenance.

Access to draught power. In marginal areas many farmers do not own draught animals for land preparation and would be forced to rely on hired animals, which introduces an additional cost element.

Access to sufficient planting material. The current project proposes 500 hectares of cassava within 4 years, but currently available stocks of planting material in Zimbabwe are only sufficient for 50 hectares. To produce enough planting material in a short space of time 200 hectares of land would be required and 2 million cassava cuttings at an approximate cost of US$30,000.

Yields. The predictions made by the project rely on a projected yield of 15 tonnes of fresh roots per hectare of cassava. This is a moderate yield for a research station and can be achieved by farmers using the correct levels of inputs and good agricultural practice. However, yields in many African countries are much lower, ranging from 4-5 tonnes per hectare to 10-12 tonnes per hectare. Low yields could adversely affect the economic viability of production.

Transport. Most of the areas selected by the project for promotion as cassava growing areas have reasonable road links to feed millers; access to transport in the field is poor with many farmers relying on head loading.

Extension support. To realise this opportunity farmers who are unfamiliar with cassava will need a high level of support from the extension services. However, in Zimbabwe the extension services are likely to have little experience of cassava, which could present a problem.

The principle economic determinant affecting this opportunity is the raw material price. Maize is a relatively expensive commodity at US$152 per tonne. Cassava, which is drought tolerant, offers the potential for a cheaper locally produced alternative to maize. If the predictions of 15 tonnes/ha can be realised cassava chips would sell for US$80 per tonne thus saving the feed miller 48% when compared to the cost of maize.

To establish a cassava-based economy in Zimbabwe Kleih proposed a 4-year pilot project at a total cost of US$475,000 (Kleih 1998). In addition to this, individual farmers groups (7 farmers per group) would require loans of approximately US$500 to cover the cost of investment in a manual chipper, concrete drying floor and various minor tools. This cost could be reduced if farmers used simple drying racks and plastic sheets in place of concrete floors.

The likely economic bottlenecks affecting successful exploitation of this opportunity are as follows:

Yield and sale price of cassava chips. It is estimated that farmers could make a profit from cassava chip production if yields are around 15 tonnes of roots per hectare and the chip price is at least US$80 per tonne (*ibid*). A sensitivity analysis indicates that cassava chip processing would become non-viable if yields went below 12 tonnes of roots per hectare or the chip price went below US$74 per tonne (ibid). The price of chips in Zimbabwe is difficult to predict but it does seem likely that yields could fall below 12 tonnes per hectare for many reasons.

Access to credit and negative cash flow. According to the project proposal, farmers will experience a highly negative cash flow in the first year of operation that would continue into the second year. This cash flow problem results from the biennial nature of the cassava crop in Zimbabwe and the requirement for a relatively high level of initial capital investment (*ibid*). To overcome this difficulty, farmers will require access to credit that does not need to be repaid in the first three years of operation; this could prove difficult, as potential financiers are likely to be reticent about investing in an untried commodity.

Demand for cassava in livestock feed. Macroeconomic problems in Zimbabwe have adversely affected demand for livestock feed and have reduced the potential for development of a cassava-based economy in the country.

In the development of this opportunity, the extension services and NGOs would play a vital role in raising awareness of the potential of cassava, and providing training and technical support for farmers on production and processing of cassava. International institutes with regional centres such as IITA could play a vital role in providing and building up stocks of high quality planting material. Financial institutions would have to be identified that could provide the necessary level of credit to enable farmers to exploit this opportunity. With the market system the feed millers would have an important role in providing access for the farmers to the feed market. As with other examples in other countries, it would probably be the miller that would need to establish a system for getting the chips to the factory and maintaining quality standards.

To realise this opportunity a number of critical factors must be dealt with, these are:

Training: Training must be provided to extension personnel in aspects of cassava production, processing and utilisation in livestock feed to enable them to support farmers and feed millers wishing to exploit this opportunity.

Supply: A sufficient supply of high quality planting material is required to enable cassava to be established in Zimbabwe.

A Market: A stable market for cassava must exist in Zimbabwe so as to provide an outlet for the farmer's product. Current downward trends in the demand for livestock feed could make investment risky.

Farm Credit: A system of rural credit is required to enable farmers to invest in cassava production and processing and to cover the initial period of 1-2 years when cash flow is likely to be negative. It would be useful if initial planting material could be provided without cost to farmers to encourage planting of cassava on marginal lands. Cassava's potential contribution to food security could provide a justification for this approach.

Access and Price: Areas for promotion of cassava must be selected with care to ensure that farmers have easy access to potential markets, and that these markets will use cassava, if available, at a price that is favourable to both the producer and user.

Cassava should be an attractive raw material for livestock feed because of its drought tolerance, ability to grow in marginal soils whilst giving relatively high yields for low levels of inputs and the fact that only a minimal level of processing is required to produce a value added product. Another important factor is that the use of cassava would free up domestic maize, typically white maize, for the domestic food market where it is a more valued commodity. Cassava, as an animal feed ingredient, has a competitive advantage over imported maize, which is more expensive than domestic maize.

To be successful in Zimbabwe, where there is no history of growing cassava, a high level of external support is required over a period of 5-10 years to ensure that cassava has a chance to become established within the country.

Although focussed on Zimbabwe the issues raised are applicable to other countries in other agro-ecologies.

Case Study: Northeast Brazil

Olivier Vilpoux and Marco Tulio Ospina

This case study discusses the implications for the cassava chip industry in Northeast Brazil. The case study is based on the recently completed adoption and impact assessment of cassava chipping & drying in the state of Ceará (Ospina et al. 1998). The *Ceará Project* was an outgrowth of CIAT's (International Centre of Tropical Agriculture) Integrated Cassava Research and Development (ICRD) project. The CIAT approach has been used in several Latin American countries to develop new market opportunities for cassava farmers. It was assumed that farmers are motivated to explore new marketing channels but require new and improved production technologies. The implementation of this strategy required cassava farmer associations and co-operatives to establish and operate small-scale agro-industries to process dried cassava chips. These chips would then be used in the animal feed industry as a partial cereal substitute.

The Ceará integrated research and development project demonstrated that the introduction of cassava chip drying technology could expand cassava markets and is a viable strategy to increase farmers' income and employment, and to improve their overall well being. The production of cassava in Ceará is enough to guarantee the successful operation of a dry cassava agro-industry Table IV-7. As illustrated, nearly 65% of the cassava harvest is devoted to flour production ("farinha"). Cassava flour is a very important staple in the diet of northeast Brazilian people "Nordestinos". Farinha is an integral part of traditional culture and its consumption is constant or perhaps even increasing. The introduction of a dry cassava chip market would have to respect this established use of cassava and not attempt to compete with the cassava flour market. Instead the introduction of the dry cassava chip market would have to complement the current market by providing farmers an additional market outlet, or a better market when cassava flour prices are low. Therefore, the dry chip market may be based initially only on the remaining 5% of production that is not traditionally processed into cassava flour.

According to the figures in Table IV-7, about 200,000 tons of cassava root in the State of Ceará could be used for dry cassava chips. However there are two considerations about these numbers[10]. First, they are based on an estimated productivity of 8.5 tonnes/ha tons in the North. Field observations in Ceará over several years indicate that the actual productivity of small-scale cassava farmers in the region is lower at around 5.5 ton/ha. They do not use any fertiliser and they do not plant 10,000 plants per ha. They also use poor quality planting material and limited weed control. Second, a high percentage of cassava producers in Ceará State are sharecroppers or renters. Landowners, and not sharecroppers, control the final destination of crop production. In many cases, the sharecroppers or renters are required by the landowners to process their cassava crop into farinha at the landowners processing plant. This is a very serious constraint in Ceará to the introduction of dry cassava industry.

Notwithstanding the potential problems associated is the land tenure system in Ceará, it is assumed that 50% of current production could potentially be used for the cassava chip industry. At a 2.5 conversion coefficient the annual production of dried cassava chips could be 47.6 thousand tons in Ceará, 200 thousand tons in the Northeast and 104 thousand tons in the north.

[10] Personal Communication, B. Ospina. Senior Research Fellow, CIAT. Cruz das Almas BA - Brazil.

Table IV-7: Annual Production and estimated uses of cassava in some regions of Brazil

Uses	Ceará State*			Northeast*			North*		
	Area 000 ha	Prod’n ‘000 t.	%	Area ‘000 ha	Prod’n ‘000 t.	%	Area 000 ha	Prod’n ‘000 t.	%
Flour	91	773	65	650	6,500	65	260	3,380	65
Hco**	28	238	20	200	2,000	20	80	1,040	20
Feed	14	119	10	100	1,000	10	40	520	10
Losses	7	59	5	50	500	5	20	260	5
Total	140	1,190	100	1,000	10,000	100	400	5,200	100

Source: (CONAB 1997) Indicadores da Agropecuaria. Companhia Nacional de Abastecimento. Ano VII, No. 4, 1998.

* Average yield: Ceará 8.5t/há; Northeast 10t/há; North 13 t/ha.

** Hco. Human consumption

According to Islabão, (1990) the basic raw materials for feed formulation in Brazil are corn and soybean meal with level of 60 to 90% for corn and 10 to 40% for soybean meal. Corn and soybean meal are primarily produced in the south and centre-west states of Brazil, which results in high transportation costs for users of feed in the northeast and north. Therefore lower priced cassava chips at US$ 130/t may be an attractive alternative in these regions as a partial substitute for other feed components, such as corn.

The factors that constrain the development of a cassava chip industry in Ceará are a lack of working capital, low cassava production surpluses and land tenure problems. The most difficult problem to resolve is the land tenure problem. Without ownership of the land, cassava farmers have to make agreements with the owners just to produce enough flour for their own consumption. As a result, there is no surplus production to sell to drying plants. In addition, lack of working capital does not permit purchases of cassava from farmers that are not members of the agro-industries.

One program currently being implemented to address the land tenure constraint in Ceará is called “Bank of the Land” and operates with World Bank and state funding. The program encourages farmers’ groups to organize themselves and identify pieces of land that are for sale. The group can then apply for a loan with soft interest rates and long-term payments to purchase the land. In some cases some communities that have already started a cassava chip industry have used the program to apply for loans to purchase land and have already begun planting cassava.

According to the Ceará Project, many farmers testified that the sale of dry cassava chips was difficult in the beginning, that markets were scattered and that farmers did not have the skills to operate the agro-industry efficiently. In addition, transportation was difficult because of a lack access to good road and vehicles.

Another problem is that the typical consumer is a small-scale cattle producer. In years of good rainfall, with abundant pastures, this consumer is not keen to buy cassava chips. Thus development of the dry cassava chip industry would benefit from a growing number of large animal feeding units requiring large quantities of cassava chips.

The experience gained through several years of dry plant operations is critical in the creation of promotion programs of the dry-cassava agro-industry. Plans and strategies have to be designed with direct participation of cassava farmers' organization. These programs require that farmers have access to enough land so that production for the operation of drying plants is adequate. Furthermore, local and government agencies have to actively encourage farmers to develop new markets in close collaboration with private sector consumers.

Consumer demand for meat, milk, poultry, eggs, and chicken is expected to continue to increase. This increasing demand will place tremendous pressure on the availability of various raw materials, among them cereals. Since the production of corn is not feasible in many parts of the Northeast and because of high transportation costs, cassava production and drying is a viable alternative to many traditional raw materials. A major constraint remains if average yields of cassava are 5 t/ ha. A significant effort must to be made to reach the feasible goal of 20 t/ha given appropriate and available technology. If these conditions were met cassava chips could be supplied at competitive prices and demand would surely increase creating a competitive cassava chip industry.

Currently many forces play a negative role in development of a cassava chip industry in Northeast Brazil. Several strategies have been designed and implemented in an attempt to address these constraints but to date none have been successfully applied. There is great potential for cassava chip production but to date the programs and conditions remain ineffective in the promotion of cassava production. In conclusion, the only way to create a competitive cassava chips industry will be to improve land tenure conditions and increase cassava yields by using appropriate technology for cassava production. This will create a production surplus that can be used for cassava chip production.

Case Study: Thailand

Boonjit Titapiwatanakun

As a partial replacement of the shrinking export market for cassava chips and pellets, the Thai industry is exploring the possibility of increasing domestic utilisation of chips and pellets in animal feeds.

In terms of technical feasibility, studies have shown that adding high-protein content raw materials and mineral supplement into the ration can solve technical problems of using cassava chips products in feed rations. For feed compounders all the technical problems are, more or less, solved. However, at the farm level, especially small holders, technical problems persist regarding the availability of certain ingredients and the appropriate mixing of feed rations. The latter problem can be overcome by using the existing extension system, as well as the activities of the Thai Tapioca Development Institute, to provide farmer training on how to mix the correct ration for farm level feeding. Research has led to the identification of several successful cassava-high protein mixes that can be used as substitutes for maize, broken rice or sorghum. These mixes are: cassava chips or pellets mixed with soybean meal at 85 kg and 15 kg, respectively; or chips/pellets mixed with fish meal at 89 kg and 11 kg, respectively. The percentages of using chips or pellets in the ration are as follows (TTTA 1997).

Table IV-8: Percentage of cassava products in the feed ration

	Maximum %	Recommended %
Boiler	58	20
Laying	60	25
Laying bird	60	25
Pig Finisher	60	37
Pig breeding stock	67	30
Beef cattle	68	50
Dairy cows	68	50

The economic feasibility of using cassava chips in the feed ration was tested by comparing the computed value of mixture between cassava and high protein feed ingredient i.e. soybean meal and fish meal at an appropriate ratio with the price of corn or maize at Bangkok wholesale level. The monthly average Bangkok wholesale price of chips, soybean meal and fish meal were used to compute the value per ton of cassava-soymeal mixture at a ratio of 80:20 and 84:16 and the value of cassava-fishmeal mixture at a ratio of 89:11. Then the computed value was compared with the monthly average Bangkok wholesale price of corn per ton.

The computed cost of a cassava-soymeal mixture at a ratio of 80:20 was lower than the price of corn for only 69 months out of the total 180 months during the period of 1983 to 1997. In other words, there were only 69 months that it was economically feasible or profitable to use cassava-soymeal meal to substitute corn in the feed ration. When the ratio of mixture increased to 84:16, then 101 months were economically profitable to use cassava-soymeal mixture. In both cases, the average price of chips in those months that the mixture was profitable was between 2,089 and 2,080 baht/ton (approximately US$ 83/ton[11]) or between 38-52 percent of the price of corn (4,066 - 3,853 baht/ton, approximately US$ 158/ton), while the price of soybean meal was between 8,973 to 8,979 baht/ton, approximately US$ 359/ton. Since 1994 it appears that it would have been economically feasible to use cassava chips in the feed ration (Figures IV-3 and IV-4)

[11] An exchange rate of 25 bath to the US dollar has been used to convert the Thai prices to US dollars.

The comparison between the computed value per ton of cassava-fish meal at a ratio of 89:11 and corn price shows that there were only 41 months that were economically feasible to use the mixture for replacing corn during 1983-1997. During the months when it was feasible to use the mixture, the average price of chips was 2,436 baht/ton, approximately US$ 97/ton, or 23 percent of the average price of fish meal (15,416 baht/ton, approximately US$ 616/ton), while the average price of corn was 4,558 baht/ton, approximately US$ 182/ton. It is interesting to note that those economically feasible months began in 1994. The three scenarios show a pattern that started in 1994 where the value per ton of cassava-soymeal and cassava-fishmeal mixtures was lower than the price of corn. This was due partly to the increasing price of corn, which increased from 2,892 baht/ton in April 1994 to 4,510 baht/ton in December 1997. It can be concluded, however, that based on the simple analysis of economic feasibility, at times it is economically profitable to use cassava mixture to replace corn in the domestic animal feed ration (Figure IV-5).

It is noteworthy that the cassava soybean or fishmeal mixes have exhibited less price variability than the corn price. In the long run feed compounders should find this to be a useful feature when using cassava and high protein rich feed mixes in their rations.

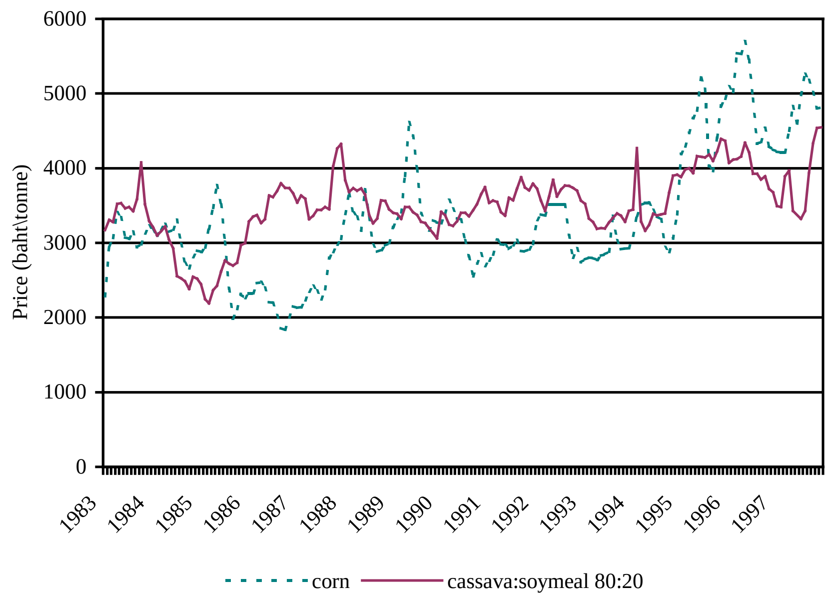

Figure IV-2: Average monthly Bangkok wholesale price of corn and the computed value per tonne of 80:20 mix of cassava chips and soybean meal

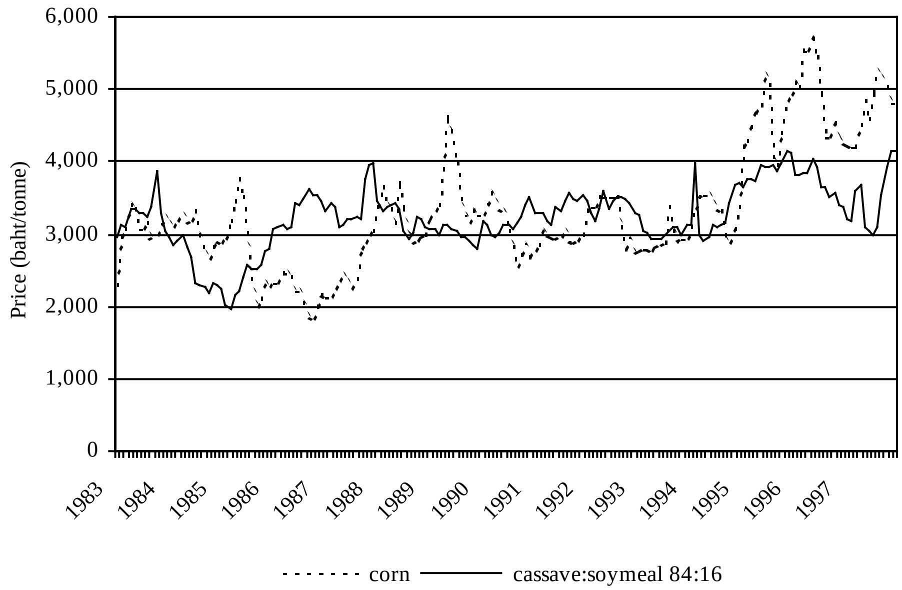

Figure IV-3: Average monthly Bangkok wholesale price of corn and the computed value per tonne of 84:16 mix of cassava chips and soybean meal

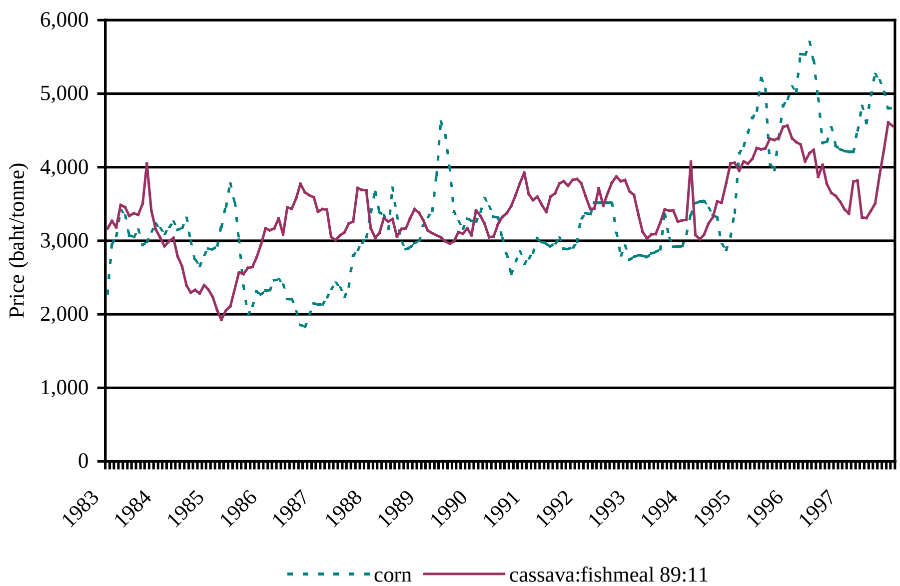

Figure IV-4: Average monthly Bangkok wholesale price of corn and the computed value per tonne of 89:11 mix of cassava chips and fish meal

Growth trends in the livestock sector have been favourable. Statistics obtained from the Thai Animal Feed Producers' Association showed that boiler, layer, aquaculture and dairy cows had the highest annual growth rates

(1995-97) of 7.5, 7.2, 7.2 and 7.0 percent, respectively, while the growth rates for pigs was about 3 percent and for ducks was about 5 percent.

The production of shrimps, which are the brackish water tiger prawn, decreased from 250 thousand tons in 1995 to 180 thousand tons in 1997. This was mainly owing to environmental problems created by the aquaculture of shrimp. In fact, shrimp growing will be limited eventually to restricted areas. The major concern is soil contamination owing to increased salination, especially in those areas where rice fields are being converted into ponds for growing shrimp.

In terms of economic factors, there has been a strong domestic demand for animal feed, which is a derived demand from the livestock industry. The major driving force of the livestock industry expansion is the increasing export of boilers and shrimp. During 1980-1995, Thai exports of frozen chicken increased from 27 thousand tons to 137 thousand tons with an annual growth rate of 15 percent. More than 75 percent of the total was exported to Japan, while the rest were exported to Germany, the Netherlands, Singapore and Hong Kong. The success of the boiler industry and frozen chicken export is matched by the export of frozen shrimp. Frozen shrimp exports increased from 18 thousand tons in 1980 to 161 thousand tons in 1997 (an annual growth rate of 19 percent). The major markets are Japan, USA, EU, Singapore and Hong Kong.

As for the domestic market, there has been increasing demand for meat and seafood, which, in turn, increased the demand for animal feed. This is owing to the increased income of Thai people and increased number of tourists in Thailand. In addition, the domestic agro-industry was able to expand in response to the increasing domestic and export demands. For example there are many processed meat and fishery products that are available in the domestic markets. These products were produced partly for export and partly to cater to domestic consumers' needs.

The major problem faced by the animal feed industry is the shortage of high protein feed ingredients. Imports of soybean meal increased from 191 thousand tons in 1983 to 790 thousand tons in 1996 (an annual growth rate of 13.7 percent). Another problem, which has a negative impact on growth, is the high sanitary and hygiene standard and regulation imposed on processed seafood, meat and meat products by the importing countries. Some of these regulations can be regarded as barriers to trade.

At present, there are 51 animal-feed compounders with a total of more than 57 factories. All are registered as members of the Thai Animal Feed Producer Association. Although the total annual capacity of these factories is not available, the annual production of animal feed is more than 10 million tons. Some of the big feed compounders utilise cassava chips and pellets as feed ingredients. However, the official data on cassava consumption is not known. The annual consumption of chips and pellets in compound feed production was estimated to be between 300-500 thousand tons. Nevertheless, scenarios using a simple analysis of economic feasibility of using chips, discussed earlier, reflected that during 1995-97 it was profitable to use chips.

Therefore, there are reasons to believe that annual consumption of chips and pellets is much higher than the estimated figure.

Chip and pellet exporters have been actively promoting the use of chips and pellets in the domestic animal feed ration through supporting research and seminars. A recent seminar revealed that one of the reasons that farmers do not use chips in the animal ration was a lack of knowledge. At present, exporters have not yet fully integrated into the animal feed compounding industry. However, there is a possibility for exporters to produce some form of cassava based animal feed to serve the local market.

The institutions involved in promoting the use of cassava product, as animal feed in the domestic market are very similar to those mentioned in the case study of modified starch. The Thai Animal Feed Producer Association and the concerned government agencies in animal feed and livestock promotion are more or less, preoccupied with the major feed gain and high protein feed ingredient problems. The Thai Tapioca Development Institute has also helped to promote and sponsor demonstrations on the use of cassava as a domestic animal feed.

The potential domestic utilisation of chips and pellets for selected animal feed were estimated using the average percentage of chips or pellets that can be mixed in the compound feed and the estimated annual feed production obtained from the Thai Animal Feed Producer Association. The total potential quantity demanded for chips in pig finisher feed was 1.1 million tons in 1997. The potential for other types of animal feed are: for boiler feed 0.6 million tons, for laying bird at 0.3 million tons, for pig breeding stock 0.2 million tons, and for dairy cows 0.18 million tons. The total potential demand for chips in the feed ration of these animals increased from 2.2 million tons in 1995 to 2.4 million tons in 1997 and it was projected to be at 3.2 million tons in 2002. It is worth pointing out that the estimated total potential demand for chips for animal feed was 2.4 millions in 1997, which is about 24 percent of the total compound feed production and it may be regarded as maximum potential quantity demanded for the time being. However, the current total domestic demand for corn for feed is almost more than the total corn production (4.3 million tons), which means the price of corn will tend to remain at the high level. This would encourage feed compounders to use chips for substituting corn in the future (Table IV-9).

In general, cassava products are used in aquaculture feed. Cassava chips are mixed with other feed ingredients in the feed ration for aquaculture of fish. The alpha starch, or pre-gelatinized starch, which is a physically modified native starch, is used as a binder in the feed ration of eels and shrimps. However, there is no information of eel production, only the estimated production of fish (the kind of fish is not specified) and trigger prawn shrimp are available. The estimated potential utilisation of cassava chips in fish feed ration increased from 30 thousand tons in 1995 to 34.5 thousand tons in 1997, and the projected potential demand in 2002 was 48.4 thousand tons. As for the feed ration of shrimp, the estimated utilisation of alpha starch was 36 thousand tonnes, which is expected to be the same in year 2002. As a matter of fact, 36 thousand tons of alpha starch is equivalent to 180 thousand tons of fresh roots or 67 thousand tons of chips. Therefore, the total potential demand for aquaculture feed in 2002 will be around 115 thousand tons of chips (Table IV-9).

Table IV-9: Estimated potential utilisation of cassava chips in feed rations of selected animals (1,000 metric tonnes).

Animal	Chip (%)	1995	1996	1997	2002
Broiler	20	476.0	547.4	567.0	872.6
Layer	25	54.2	54.2	68.3	120.3
Laying bird	25	270.0	300.0	310.0	434.9
Pig finisher	37	1,036.0	1,087.0	1,098.2	1,272.8
Pig breeding stock	30	209.3	220.4	231.6	295.5
Dairy cows	50	153.3	153.3	176.3	247.3
Sub-total		2,198.8	2,363.1	2,451.4	3,243.4
Shrimp	10	50.0	50.0	36.0	36.0
Fish	15	30.0	30.0	34.5	48.4
Sub-total		80.0	80.0	70.5	84.4
Total		2,278.8	2,448.1	2,531.9	3,327.9

Note: The estimated cassava product used in shrimp feed is in terms of alpha or pregelatinized starch that is modified from native starch at a conversion ratio of 1:1.

The lessons learned from the Thai experience demonstrate one, the importance of the export demand as a driving force behind the growth of the chips and pellets industry. This in turn raised domestic prices and prevented domestic utilisation. Two, that a unique marketing approach was required to encourage the domestic use of cassava products as an animal feed. Three, that cassava and non-cassava related industries require linkages across the industry if mutual benefits are to be realised.

Conclusions

As noted at the beginning of this Chapter the domestic animal feed market can be a growth market for cassava. But even in a country such as Thailand, cassava must be competitively priced against competing commodities. On the other hand, the use of cassava in animal feeds can free up the use of maize and competing crops for other markets where they have a comparative advantage. In Zimbabwe the use of cassava chip could create a market that does not currently exist. In the case of Thailand, the domestic use of cassava could free up maize for other domestic or export purposes.

Again the Thai case illustrates the importance of the size of the market. While the data are incomplete, Thailand is currently using about 500,000 tonnes of chips/pellets in domestic animal feed. The analysis indicates that by 2002 Thailand could use as much as 3.3 million tonnes of chips/pellets/starch for animal feed. This is approximately equivalent to 8.3 million tonnes of roots. Given that Thai cassava farmers tend to be small the domestic animal feed market could be a market for over 250,000 farmers.

The Ceará Project also demonstrates that the animal feed market in Northeast Brazil could utilize a substantial amount of cassava and provide a growing market opportunity for a large number of cassava producers.

The Zimbabwe case study illustrates that the animal feed market for cassava may be attractive even in a relatively small market situation. The Zimbabwean example also suggests that a cassava chip/pellet industry could be developed in conjunction with the development of a more intensive animal feed industry.

An interesting feature of the three case studies is that the actual or target price of cassava roots and processing ranged from US$ 30/tonne for Thailand and Zimbabwe to US$ 52/tonne for Ceará. This compares favourably with the maize import substitution target price of US$ 58/tonne to US$ 75/tonne, calculated at the beginning of the chapter.

Part 2: Export Market Opportunities

Truman P. Phillips

Cassava is exported in three forms: as a human food, as a starch, and as an animal feed ingredient. Similar to the domestic markets, price and quality competition exists in the starch and animal feed markets export markets. There is less competition in the human food export market.

The cassava export markets are primarily Europe and North America. There are a number of important but smaller markets in Asia, such as Japan, Korea and China. The export market for cassava chips and pellets and cassava starch is highly price competitive. There are other *barriers to entry* owing to the large scale of some of the market, quality requirements, variability in price, and the established contacts between European and North American importers and the major exporters such as Thailand and Indonesia (Figure 1). This is not to say that other cassava producing countries cannot enter these markets, but they need to realise that the export market is not for all cassava producing countries.

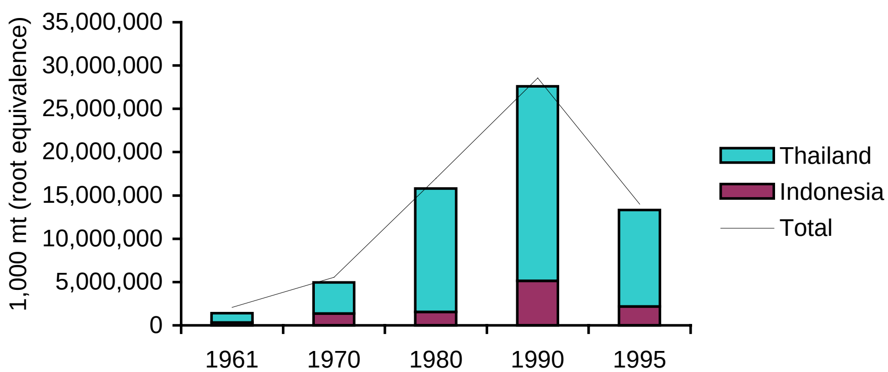

Figure 1: Exports of cassava

Only 10 countries managed to export more than 10,000 tonnes (root equivalence) in 1995 (Table 1). As can be seen from the above figure, Thailand and Indonesia account for 95 percent of the exports. Thailand is the leading exporter of cassava starch and cassava pellets for animal feed. Indonesia's exports are primarily in the area of cassava pellets and chips for animal feed. Costa Rica, normally the third largest exporter, exports fresh cassava for human food[12]. The major export of the remaining countries is in the form of starch.

[12] Indian exports of tapioca were unusually large in 1995.

Table 1: Major cassava exporters 1995 (tonnes root equivalence)

Country	Exports	Country	Exports
Thailand	11,137,150	Tanzania	84,000
Indonesia	2,181,036	Brazil	82,991
India	149,008	China	39,810
Costa Rica	118,226	Philippines	39,681
Viet Nam	87,143	Madagascar	26,948

The importer side of the picture is slightly more diverse. In 1995 22 countries imported more than 10,000 tonnes of cassava (root equivalent) (Table 2). The data in this table are a little misleading. For example the 1995 Indonesia import of cassava is an aberration. Also Australia, Bangladesh, Argentina and Mozambique have not been traditional importers of cassava. Finally Japan and the United States have imported substantially more than they imported in 1995. Nevertheless, the table is instructive. It illustrates that the demand side of cassava markets are more variable than the supply side. Depending on a country's risk preference, they may see the export market as an opportunity or a risk.

Table 2: Major cassava importers 1995 (tonnes root equivalence)

Country	Exports	Country	Exports
Netherlands	3,476,058	France	229,375
China	2,340,135	USA	181,495
Spain	2,059,143	Hong Kong	152,893
Bel-Lux	1,233,320	Australia	48,050
Portugal	1,014,516	Philippines	42,835
Indonesia	872,169	Colombia	28,083
Malaysia	616,864	Bangladesh	23,900
Korea Rep	488,623	Argentina	17,016
Germany	379,079	UK	13,895
Japan	362,417	Canada	11,662
Italy	234,274	Mozambique	10,800

The following chapters contain a review of some of the important markets for internationally traded cassava.

Chapter V: Cassava Foods

Global Opportunities

Truman P. Phillips

The consumption of cassava as a staple in non-cassava producing countries is generally restricted to immigrants who learned to eat cassava in their country of origin. For others, they tend to know cassava as a novelty food or a desert, not as a staple. During the course of this investigation three promising cassava food market opportunities were found in North America and Europe. These export opportunities may also exist in other regions of the world (such as Japan, S.E. Asia, etc.) but they were not examined in this report. The markets are fresh, dried and frozen cassava; cassava flour as a replacement for gluten based flours; and cassava based snack foods. The issues surrounding these markets are discussed below.

Case Study: North America

Daphne S. Taylor

1.1. Fresh Cassava

Fresh cassava is generally treated as an exotic tropical vegetable in North American grocery outlets. In 1997 the U.S. imported 35,000 metric tons of fresh, dried, chilled and frozen cassava. Canada imported 1,859 metric tons of fresh, dried, chilled or frozen cassava. The annual growth rate of fresh cassava imports into the United States since 1989 has been 24% and for Canada 30% (Figure V-1).

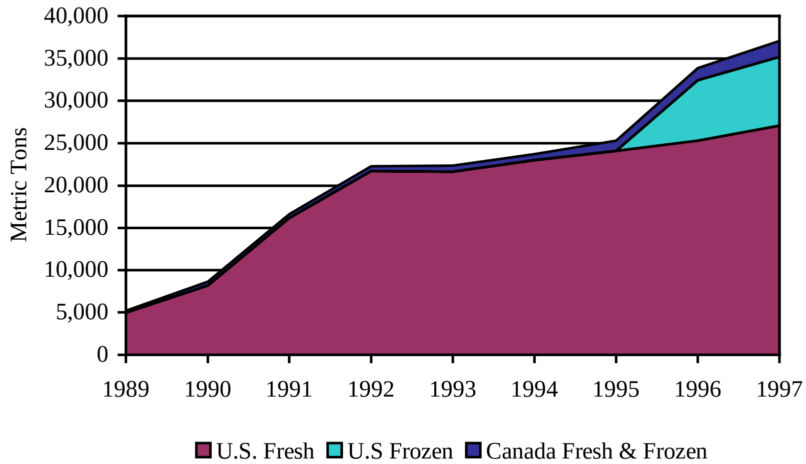

Figure V-1: Fresh, dried, chilled and frozen cassava imports into North America

The average U.S. import unit price for fresh cassava root in 1997 was $13.70 per 50 pounds (or $604 per metric ton). The average U.S. import unit price for frozen cassava root in 1997 was $15.27 per 50 pounds (or $673 per metric ton). The terminal prices at various locations across the United States as of June 30 1998 ranged between $16 in Miami and New York City to $22 in Los Angeles per 50-pound carton (Table V-1). The retail price at a local grocery outlet in rural Southern Ontario was $0.61 U.S. per pound or $1.35 U.S. per kg.

Table V-1: Price of waxed yuca/cassava from Costa Rica per 50 pound carton

Terminal	Prices on June 30 1998
Miami FL	$16.00-18.00
New York NY	$16.00-18.00
Baltimore MD	$18.00-20.00
Philadelphia	$19.00
Boston MA	$19.00
St. Louis MO	$19.00-19.50
Los Angeles CA	$20.00-22.00

Source: (USDA-AMS Market News Service)

The increase in fresh cassava (yuca) imports is driven by three factors. One factor is the development of new techniques that extend the shelf life of tubers, and allow them to be exported. A second factor is the increasing ethnic populations in both the United States and Canada who are familiar with cassava. A third factor is a growing interest in ethnic foods by main stream Americans and Canadians. This increased demand has occurred both in grocery outlets and restaurants.

Fresh roots for export are typically coated with paraffin to prevent deterioration. Tubers are dipped in a fungicidal wax for 1 minute, drained, dried and stored at room temperature. The process reduces loss in weight and can prolong shelf life of tubers up to 1 to 2 months (Balagopalan et al. 1988). Once shipments reach the grocery outlet the tubers are said to last about a week. Alternative packaging approaches include shipping cassava in sealed plastic bags filled with CO_2, or chilled/frozen cassava tubers. As illustrated in Figure V-2 much of the recent growth has been in the frozen import category. Some of this growth may be artificial, however because the U.S. only recently separated imported chilled and frozen cassava from imported dried and fresh cassava in 1995. It is not known how much frozen cassava, if any, was imported before 1995.

A second reason for the increased demand for fresh cassava is the large immigrant populations in Canada and the U.S. In the U.S. the Hispanic population is assumed to be a major driving force in market expansion, while in Canada the driving force is assumed to be the Caribbean population. In 1996 the Hispanic population in the United States was estimated at 29 million persons representing 11% of the U.S. population with a median age of 34. By the year 2050 the Hispanic population is anticipated to be 96 million persons, representing 25% of the U.S. population with a medium age of 38 (U.S. Department of Commerce Bureau of the Census 1997). If one assumes the consumption rate of fresh cassava by the Hispanic population[13] remains constant at approximately 2 pounds (or .9 kg) per year per person then imports of fresh cassava could more than triple by the year 2050, as illustrated in Figure V-2.

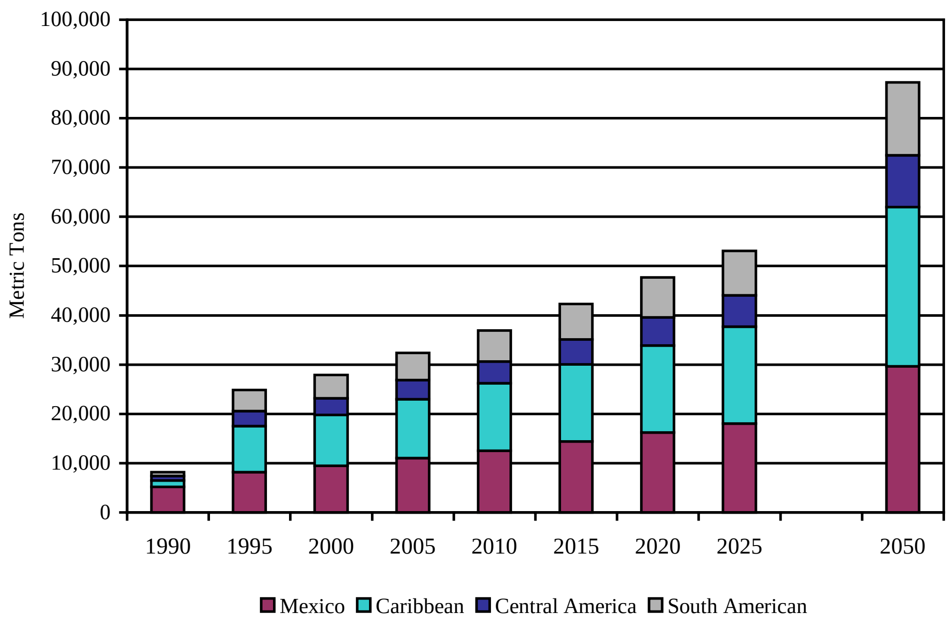

Figure V-2: Potential cassava consumption owing a increasing Hispanic population

[13] In 1995 the percentage of “Hispanic” immigrates from Mexico was 34%, from the Caribbean 37% (mainly from Dominican Republic), from Central America 12% (mainly from El Salvador) and from South America 17% (mainly from Colombia).

A third factor contributing to the increase in cassava imports is the changing face of grocery supermarkets in North America. Traditional supermarkets are facing stiff price competition from large warehouse buyers clubs such as *Price Costco*. To compete, supermarkets are introducing bulk sized products, centralized buying, just-in-time ordering and diversifying their outlets to meet the specific needs of regional and ethnic markets. In the greater Los Angeles area, for example, *Yucaipa's Food 4 Less* caters specifically to Latino customers and is the second largest supermarket operator in the area. To attract ethnic clientele, supermarkets are using products like cassava as a marketing tool often times as a *loss leader*. The same thing is happening in traditional supermarkets in Canada. The stores don't expect to sell very much cassava but they recognise the need to have it available (personal communiqué).

Finally, there is reason to believe that the urban population of North American is gaining an interest in ethnic foods. A survey of 635 respondents found that 45% agreed that they would be interested in experimenting with ethnic foods and would like to try items they have never eaten before. Fifty percent of adults wished more ethnic dishes were available at moderately priced restaurants and 40 percent wished they were available at fast food places, a less traditional setting for ethnic items (National Restaurant Association 1989). Thus fresh cassava may find a growing market in Caribbean and Latin American restaurants in the future.

Costa Rica has effectively cornered the fresh cassava market into the U.S. supplying over 97% of U.S. imports[14]. The Philippines ranks a distant second at 1% of the market. Suppliers to the Canadian market are more varied. In 1997 Costa Rican suppliers represented 41% of the total Canadian import value of fresh, frozen or dried cassava, Jamaica 33%, Philippines 10%, the United States 9% and Vietnam 3% (Government of Canada).

The potential growth for fresh, dried, frozen and chilled cassava in North America is good for numerous reasons; a growing ethnic population familiar to cassava, a growing trend in the overall consumption patterns towards ethnic foods and better technologies for prolonged shelf life. A major constraint to the expansion of the North American market for fresh, dried, chilled and frozen cassava is the lack of product recognition by the non-immigrant population. While a higher percentage of the population has seen cassava than any time in the past, they have little idea what the product is or how to prepare it. Cassava has not been promoted. To simulate new demand, market promotion is essential. One cannot expect to use cassava as a loss leader indefinitely. At some point in time cassava must be profitable to sell.

The perishable nature of the crop is another bottleneck to market expansion. Obviously, if a dehydrated or frozen french-fry product were developed then storability is not a problem. While cassava (yuca) in North America does not have close substitutes or complements, it may lose consumers, as immigrate populations become integrated into North American culture. New immigrants

[14] In value terms.

are likely to replace cassava with potatoes, as it is similar in preparation and cooking style and adds similar properties and tastes to meals.

The similarity between potato and cassava consumption makes one think that it might be possible to model future cassava consumption after the potato experience because both are labour intensive to prepare and are subject to spoiling. Over time fresh (unprocessed) consumption of potatoes in North American has been replaced with processed and frozen potato consumption, as illustrated in Figure V-3 (Hillstrom).

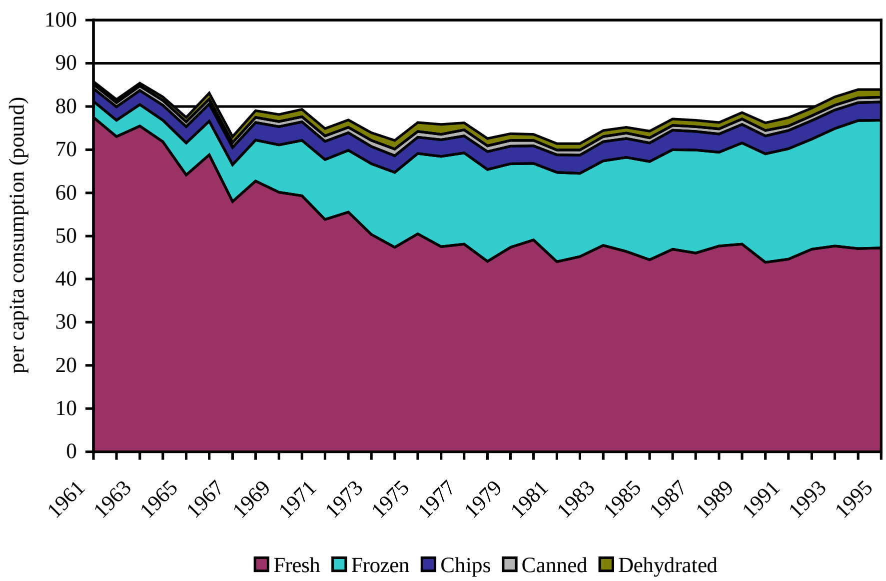

Figure V-3 U.S. Consumption of Potatoes by product

Thus, it could be suggested that further processing of cassava such as dehydration might be one value added activity that could be done by exporters. Over the past 35 years, consumption of dehydrated potatoes has grown at a rate of 3 percent per year. Although consumption of dehydrated potatoes accounts for only 2% of total per capita consumption it is an area that might be promising for cassava.

An alternative would be the development of cassava french-fries (see Brazilian case study). As can be seen from Figure V-3 this has been the greatest source of growth for potatoes, with an annual growth rate of 8 percent.

The demand for fresh, dried, chilled and frozen cassava has increased owing to improved packaging and processing and increased demand by consumers. While the trend is positive, it would appear there is a need to further develop an acceptable line of products to expand the consumer base. From the supply side Costa Rica has taken the lead in developing new processes, products and markets. On the demand side supermarkets have been pro-active in targeting and developing ethnic markets, but in general have not done much to promote cassava consumption itself. There is a need to promote fresh, dried, chilled and frozen cassava if this market is to maintain a long-term growth trend.

1.2. Cassava Flour

In addition to the fresh, dried, chilled and frozen consumption, cassava can be consumed as a food ingredient. This section contains an examination of the potential for growth in cassava flour.

Cassava flour can be used in making breads, biscuits, salad dressings, custard powder, ice cream powder, flakes, vermicelli, etc. Cassava flour imports into North America is the smallest of the four categories of cassava import. In 1997 the U.S imported 1,592 metric tonnes of cassava flour, a dry milled product produced from peeled roots. In Canada 337 metric tonnes of cassava flour were imported (Figure V-4). As illustrated, supplies into the U.S. are quite variable from year to year peaking in 1991 and 1996. Supplies into Canada are relatively stable.

In Canada cassava flour is imported from Taiwan, Japan, the U.S., India, Hong Kong and Thailand. In the U.S. cassava flour is imported primarily from China, Japan, Thailand and Malaysia (Government of Canada).

Cassava flour plays a very small part in the North American food industry. Demand could rise, however, if the potential and need for non-glutinous flours is recognized. Cassava flour, like corn, rice and potato flours, is non-glutinous making it different from the flour of wheat rye, triticale, barley and oats. It is the gluten in these flours that help bread and other baked goods bind and not crumble. This feature has made gluten widely used in the manufacturing of many processed and packaged foods.

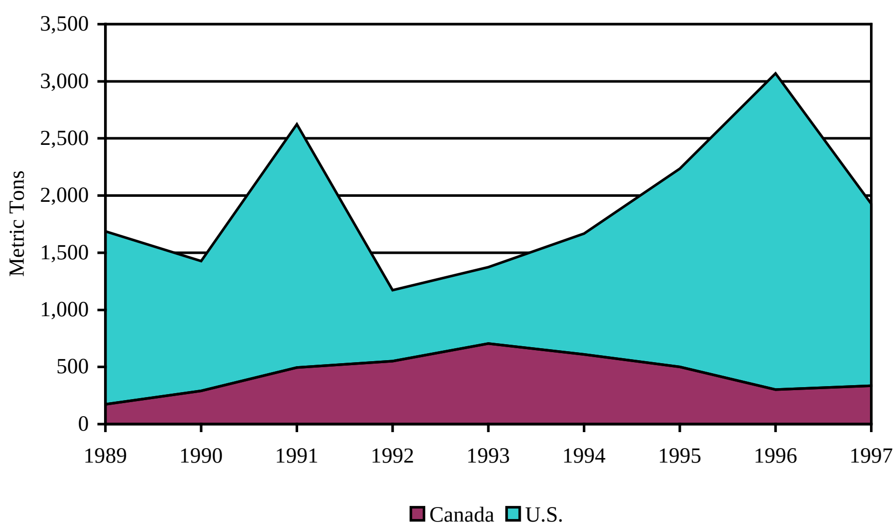

Figure V-4: North American imports of cassava flour

One reason for the demand for non-glutinous flours to increase is a growing awareness of Celiac Disease in North America. Celiac Disease is a medical condition in which the absorptive surface of the small intestine is damaged by gluten. This results in an inability of the body to absorb nutrients: protein, fat, carbohydrates, vitamins and minerals. The common symptoms are anaemia, chronic diarrhoea, weight loss, fatigue, cramps and bloating, and irritability. A definitive diagnosis can only be made by a small bowel biopsy.

Celiac Disease, as yet, has no known cure but can be effectively treated and controlled by strict adherence to a gluten-free diet for life. Acceptable flour substitutes include rice, potato, soybean, corn, arrowroot and tapioca. Rice flour is the most commonly used flour by this population.

Although statistics are not readily available, it is estimated that 1 in 5000 persons in the United States (Gluten Intolerance Fact Sheet) and 1 in 2000 in Canada (Canadian Celiac Association) are affected by Celiac Disease (Table V-2). These rates however may reveal only the tip of the iceberg as up to 25% of adults report some adverse reactions from eating specific foods (Food Allergy Center). Until recently Celiac Disease was recognised mainly in children. The rate at which adults are being diagnosed is increasing, particularly those in the 40-50 year old age bracket, owing to greater awareness and improved diagnostic skills.

To date large food manufactures have not developed or marketed gluten free products, because the market is considered to be too small - representing only 0.02 percent of the US population and 0.05 percent of the Canadian population. However from the point of view of a cassava exporter, the market could be about 6,000 tons of flour or 24,000 tons of roots.

Table V-2: Estimated Population affected by Celiac Disease, 1996

Country	Cases of Celiac	Affected Persons
Ireland	1:300	11,846
Norway	1:1,200	3,623
Canada	1:2,000	14,840
United States	1:5,000	53,888
Switzerland	1:9,000	802
France	1:200,000	291

Source (Cooley 1997)

Lacking a commitment by the large food manufacturers, people afflicted with Celiac disease must make their own bakery and gluten-free products, or buy them from speciality shops at a premium price. These individuals also have to avoid many pre-prepared and restaurant foods because wheat flour is often included, but not mentioned in the labelling[15].

[15] The Canadian Celiac Association identifies over 2,300 food items that were found to be gluten-free. These products range from baby foods, to deli meats, to dressings to snack foods. The point being that there are many more foods that are not gluten-free. (Canadian Celiac Association 1998)

The need for gluten-free foods is obvious, but to date there has been limited development in this area. A major North American importer of cassava products says that he has tried to develop this market because of its great potential for the use of cassava flour and starch. He unfortunately reports that the major food manufactures do not consider the market to be big enough. The Canadian Celiac Association reports similar problems with a gluten-free breakfast cereal that was removed from the market because the manufacturers felt that the market was not big enough (personal communiqués).

While one must be sanguine about the market opportunities for cassava flour in North America, the following experiences from England suggest that this market could develop.

The following illustrates one example of an English company that is aware of this problem and is trying to serve people with Celiac Disease.

> ***Gluten Free Foods Ltd.*** *As people become more aware of Celiac Disease they will demand healthier eating alternatives. Today gluten free products are keenly sought within the marketplace by an estimated 100,000 Celiacs living in the United Kingdom. Gluten Free Foods Ltd. was established in 1970 to meet the needs of this demand. The first manufacturer to expand the gluten and wheat-free market to include "luxury" items Richard Ward, the Managing Director, introduced the world to its first Gluten Free Bakery with products such as biscuits and cookies, pasta, pretzels and chocolate covered wafer bars (Glutten Free Foods Ltd.)*.

There are researchers who are also developing new gluten-free products as illustrated below.

> ***Anti-Allergic Cereal Based Noodles****: A research team led by Dr. Toshiyuki Arita of the Tokyo Metropolitan Food Technology Centre has developed a technique to produce anti-allergenic noodles from millet. Arita's development is noteworthy because millet species generally lack glutinosity, a feature regarded as essential for noodle manufacture. The team overcame this obstacle by adding sodium alginate (1% content) and tapioca starch to the millet as binding agents, then immersed the formed noodles in a calcium lactate solution. This led to the formation of calcium alginate in the noodles, which further augmented the binding effect. The noodles are aimed at people who suffer from allergies caused by wheat flour (Arita).*

If this market is to be realized it is going to take a concerted effort by those affected by the disease and manufacturers and distributors of bakery products.

1.3. Cassava Snacks

A second opportunity for processed cassava in North America is the so-called "salty snack" food industry. Snack foods are a fast growing industry. Dollar sales of such snacks foods grew from $10.6 billion in 1987 to $13.8 billion in 1992, an increase of 30%. Per capita consumption jumped from 17.49 pounds in 1987 to 20.55 in 1992 (Hillstrom).

Two major changes that have occurred in the industry have been consumers' concern with salt and fat intake and consumers' willingness to experiment. Low-salt and low-oil potato and tortilla chips have been developed and successfully marketed, as have multigrain snacks. Pretzels and nuts have also seen steady growth owing to consumer perceptions that they have more nutritive value than potato chips. The introduction of more flavour varieties such as salsa, spicy hot, jalapeno, and chilli illustrates the willingness by consumers to experiment.

One area where cassava might grow is the production of third generation (or extruded) snacks. Third generation snacks or pellets are made from several different raw materials. A typical recipe for snack pellets might include 55% modified cornstarch, 28.0% modified wheat starch, 16% tapioca starch, and 1% emulsifier. Following extrusion cooking, the pellets are dried to reach their final texture. After frying in hot oil or puffing in a hot air steam they are ready to eat. This last step can be carried out by the snack processor or left for the packers prior to packaging. The pellets can also be retailed as a consumer item to be fried in the home or restaurants.

The marketing potential of third generation snacks is in their stability during storage and high bulk density of packaged non-expanded pellet. Furthermore, the versatility and unique final product normally yield a higher gross profit than standard direct expanded snacks.

Certain desirable formulations, particularly those containing high levels of tapioca and potato starch have characteristics such as low gelatinization temperatures, development of high viscosity's during gelatinization, high water absorption and specific binding properties that historically have made them extremely difficult to process. In third generation snacks, it is common to formulate based upon these starches because of their inherent functional properties. Tuber starches, especially tapioca, are basic to many third generation formulations in Asia. Tapioca starch is very desirable in these snacks due to the following factors: little or no lipid content, longer amylose chains, low protein content, low gelatinization temperatures, medium size starch granules, excellent binding properties, bland flavour, and white colour.

A bottleneck however is that although extruded snacks are no higher in fat content than potato chips and corn chips they suffer from a consumer perception that they are highly processed and therefore not as healthful as related snack foods. Throughout the last decade consumers have shown a preference for more natural, less processed foods – including snack foods. Although consumers want convenience, there is a trend toward the use of whole foods rather than refined foods.

A further bottleneck is that those that attempt to compete against the large snack food manufactures typically must find a niche product that can be sold through alternative markets first, such as health food stores or ethnic markets. If the product meets with success there, the smaller marketer can charge a higher price. If the product or method of processing is really successful the smaller marketer is typically bought-out by the larger manufacturers for wider distribution.

The snack food industry is dominated by Frito-Lay (a subsidiary of Pepsi Co.), which claims 72% of the overall salty snack food market in 1997. Although the industry has elements of a monopoly, Americans' appetite for speciality and relatively "healthy" snacks has kept the industry competitive. Over 400 new products were introduced in both 1991 and 1992, including several varieties of multigrain chips, flavoured ready-to-eat popcorn and diet cheese puffs. Potato chips however, continue to lead the way in salty snack consumption in 1992, with 32% of retail sales volume. Tortilla chips were second with 19% of the dollar sales. Cassava based snack foods that do exist in North America are typically imported for ethnic markets and consumed by people who are already familiar with the product.

The good news is that the snack food market is expected to continue its rather rapid growth. It is not clear however whether cassava will play a significant part in this growth. On the positive side if cassava snacks were to be perceived as low-fat, low-salt alternatives to current snacks it's potential could be great. If however, consumers continue to believe puffed snacks are unhealthy then the potential for cassava snacks is poor.

For both the cassava snack food and cassava flour markets, there is probably limited potential for exporters of cassava to expand these markets. Cassava exporters can promote the virtues of their product, but will probably have to rely on the major food manufacturers, food technologist and consumer preferences to determine if there are growing market opportunities for processed cassava as a human food.

Case Study: Europe

Guy Henry

1.4. Fresh Cassava

Europeans have imported fresh cassava roots for many years from a variety of African and Latin American countries (Henry, Westby, and Collinson 1998). Import volumes were highly erratic, until Costa Rican exporters entered the market and gradually assumed the dominant role. Presently, Costa Rica exports 4-5000 mt/yr to European destinations. Unlike competing exporters, Costa Rican exporters (mostly of Cuban origin) work with strict quality standards and product certification. This together with efficient distribution and price management has assured them this niche market. Currently, in supermarkets and speciality food outlets of major cities in France, Belgium, Holland, UK, Germany, one can find high quality cassava roots on sale, year round. According to the importers, the main consumers are resident ethnic groups (or descendants) from Africa and Latin America (and to a much lesser extent Asia).

European fresh cassava imports, during the last 5-year period have been growing by 5-8% annually. However, the current estimated total volume of 5,000 mt/yr. is relatively small compared to US imports of 35,000 mt/yr. The latter imports are increasing by a similar annual growth rate. While Costa Rican exporters express optimism about future market growth, French and British exotic food distributors seem more conservative in their expectations. On the other hand, there is a lot of interest from other Latin countries (Colombia, Nicaragua, Cuba) to attempt to compete with Costa Rican exporters.

Future fresh cassava growth potential is determined by, first, continued consumption by ethnic groups, currently forming the principal consumer group. If we assume that their numbers grow at the average population growth rate, there would be an annual 1 to 2 percent consumption increase, if relative prices remain the same. However, second and third generation ethnic descendants, in time, may loose their taste for, or at least decrease their intake of fresh cassava.

Second, the ethnic groups may increase their cassava purchases if the relative cassava root price would decrease. Current cassava prices in Europe are very high compared to other "non-exotic" carbohydrate sources. Along the same lines, fresh cassava purchases may increase slightly as ethnic groups' incomes increase.

Third, future improved distribution can make fresh cassava more widely available, which will strengthen overall demand. However, the main determinant of growth is the potential shift of consumer groups. If "native" Western Europeans learn to appreciate more exotic foods, including cassava, future demand would significantly expand and become more sustainable. However, this is a very slow process and will take a major publicity investment. Nonetheless, there seems to be an emerging trend already. This could be helped by a growing awareness about the social aspects of purchasing (eating) products "produced by poor farmers in LDC's".

Finally, ethnic consumers in Europe are mostly Africans, whose traditional cassava consumption methods are not fresh cassava root, but rather processed cassava pastes or flours[16]. On the contrary, in the US, the main consumer group consists of Latinos, who traditionally prepare food dishes using fresh cassava roots. This would then suggest that per capita cassava consumption levels by ethnic groups in the US are significantly higher than in Europe.

From the demand and marketing side, opportunities exist in the reduction of marketing margins, expansion of product sales points and penetration of new consumer groups (advertising).

From the supply side, opportunities exist in reducing fresh root and processing costs and improving product quality. The latter mainly refers to the

[16] The imports of processed cassava for human consumption, will be discussed in a later section.

way the roots are currently being preserved with a paraffin layer. This method may not be appetizing for the final consumer. Alternative preserving options (plastic bag method) may be called for.

There is also the bottleneck of the semi-monopolistic export position of Costa Rica. West African countries have a potential edge in supplying Europe, because they can provide African varieties and products and could possibly have lower shipping costs. Nevertheless, they have a long way to go to rival the Costa Rican efficient and effective marketing methods.

Given the previous discussion on fresh cassava growth potential, the key players for the realisation of future growth are exporters and European market agents. Improved production, processing and marketing strategies could reduce root prices and margins, improving quality and expanding demand through increased awareness by new consumer groups.

While historically, fresh cassava root imports into Europe have been increasing, total volumes are still rather small compared to the US. Because of ethnic differences and related food habits, cassava consuming ethnic groups in Europe have lower per capita fresh cassava consumption levels than do those in the US. Historical import growth rates are not sustainable for the long-term future, unless fresh cassava becomes more acceptable to "native" Western Europeans. Improved quality (preservation and packaging), reduced marketing margins, increased distribution and stronger competition from other major exporters may further boost future demand. The major stakeholders for this development are principally market agents. A potential role for R&D interventions seems to be relatively minor.

Another area of growth for cassava as a food in Europe is the further processed convenience food, frozen cassava fingers (à la French fries). Although, one source mentioned that this is already being marketed in Germany and the UK, little hard evidence exists to quantify this. However, it ought to be discussed as a potential new product, since this product is recently experiencing an increasing (but still modest) success in Brazil[17] and Colombia. Furthermore, it seems that it is now also appearing in Miami supermarkets (imported from Central America), and it has been mentioned that it is being exported from Brazil to Japan. The most common product is a pre-cooked deep-frozen cassava finger in 1-lb. packages, to be found in the supermarket, next to the deep-frozen (potato) French fries. In Brazil, deep-frozen cassava is priced 10-15% below prices of the latter product. The same type product, not pre-cooked is also being sold, but is supposedly to be of lesser quality and convenience.

Of the aforementioned cassava processed products, it seems of most interest to discuss the potential for frozen cassava fries to enter European consumption patterns. The principal reason would be its characteristics as a relatively cheap (vis-à-vis potato fries), tasty, exotic and convenient carbohydrate to be consumed during regular meals or as a snack. As such, it could well compete with other upmarket frozen ready-to-eat carbohydrate

[17] A further more in-depth discussion can be found as a case study in Brazil, in Chapter I.

products, enjoying similar demand and income elasticities and subsequent positive future growth rates.

The major constraint with deep-frozen pre-cooked cassava fries in Europe is the consumer's non-recognition of cassava. Consumers have never heard of cassava, other than being used in animal feeds. This point was brought home when asking several major European frozen food manufacturers and distributors, who answered: "cassava, what is that…? Deep-frozen, next to (potato) French fries…" There is no product familiarity or recognition among "native" Western Europeans. To penetrate the market with such a product would require a considerable marketing strategy and investment. This issue of non-recognition applies to all other possible cassava based snack, fast or convenience food products.

1.5. Cassava Flour

Besides fresh cassava roots, one can find imported (mostly from Africa) traditional cassava flours and pastes (*gari, attieke, fufu*, etc.), much prized by African ethnic groups. Even if one could find statistics regarding imported volumes and values, it wouldn't say much, because according to French and Belgium exotic food wholesalers, a significant volume of these products are also illegally coming into Europe and disappear unofficially into a grey/black food market. The main reasons for this black circuit is that some of these products are just not available in shops, and the quality of some of these products are not up to strict European sanitary import regulations. Although volumes and growth rates are unknown, suffice it to say that these products, most probably, do not present potential as a major development path.

1.6. Cassava Snacks

Another cassava-based product that has made a more significant development already in some Western European countries, is the type of cassava starch cracker, called "krupuk" in Indonesia, where it has its origins. During the last 5 years, an increasing variety of krupuk-type snacks have been finding their places in the supermarkets, beside well-known potato and corn chips, etc. Although many types exist, they all have some basic ingredients in common: cassava starch and some flavouring. The latter goes from shrimp, fish, peanut, coco, to chilli flavours. In general they are priced in the higher quality snack range. Given that they are basically a processed cassava starch, they formally fall into the starch-for-food-industry category. Suffice it to say that although increasingly popular, total starch volumes for these products are negligible compared to other major starch using industries. Another potential cassava based snack food that could be brought to Europe is fried cassava chips (crisps).

Theoretically, more cassava based processed food products do exist (and may have a potential in European markets), but most are not directly identifiable as cassava products. Hence, these will be generically included in the cassava starch-for-food-use category, dealt with in the starch section of this report.

Given the previous discussion about current market constraints, the principal stakeholders that face these challenges will be the food industry itself. However, national and/or international R&D institutes could play a role as catalysers and transfer agents of technologies and information about the potential of cassava in these food product markets.

Imported traditional (African) processed cassava products seem to be a product line for a very specific and limited consumer audience. In the absence of non-ethnic European uptake, these small imported volumes should not significantly expand in the future. Improved product quality could expand the product portfolio and subsequently improve demand to some extent. Cassava based snack and convenience food products have a basic potential, but this can only be realised through a very significant marketing, and to a lesser extent, product development investment by a leading food product manufacturer and distributor. The major problem with these “new” products is consumer non-recognition. R&D interventions are limited to a role as transfer agents of cassava product technologies and information.

Conclusions

The import market for cassava as an imported food in North America and Europe is not very large and constitutes a number of products. In a majority of these markets the driving force appears to be the ethnic community - a community that may be loosing its taste for traditional dietary items.

Thus for these markets to grow there is a need to expand the consumer base. While there are indications that the wider North American and European populations are interested in new "exotic" foods, there is a need on the part of producers, processors and distributors to package, price and promote cassava foods. Promotion of cassava foods has benefited from some technological changes, such as paraffin coating of roots, frozen cassava chips and third generation snack food technology.

Perhaps the most exciting market is that for cassava snack and convenience foods. These are rapidly growing market segments in both Europe and North America that have substantial R&D and promotional support. Cassava is attractive in these markets because it has some desirable properties, and may be considered to be a novelty product in other areas. Unfortunately the growth of these markets will not be realised without the support of the major food manufacturers such as Frito-Lay, McCain's, etc.

Niche market opportunities exist, such as the use of cassava flour for bakery products for individuals with Celiac Disease. By definition niche markets tend to be small, and hence require support of the various stakeholders if the markets are to be developed.

A hopeful by-product of North America and Europe research and development in the area of food technology could be the identification of market opportunities that are more appropriate for cassava producing countries. Cassava producing countries will hopefully be able to adopt these technologies for domestic use, and the establishment of industries that spur rural development.

Chapter VI: Cassava Starch

Global Opportunities

Truman P. Phillips

The export market for cassava is highly competitive and in many cases relies on the development of innovative products. Because cassava starches are intermediate products they need to meet the needs of the final product. Therefore it is quite difficult to develop and expand the cassava starch markets without a good understanding of how the starch is going to be used. Much of the industry depends on cooperation between starch producers and starch users.

As shown in Table VI-1 and Table VI-2, the number of countries importing cassava starch is quite diverse but concentrated with only four countries (China, Indonesia, Malaysia and Japan) accounting for 82 percent of world imports in 1995. The exciting discovery is that the import demand for cassava starch increased substantially after 1980, with the development of modified starches, and has continued to grow in 1995.

Table VI-1: Cassava starch imports (mt)

Country	1970	1980	1990	1995
China		34,649	219,891	238,007
Indonesia			2	172,472
Malaysia	10	3,592	9,967	122,474
Japan	50,258	67,249	109,932	76,228
Singapore				30,860
Hong Kong				21,352
USA			16,050	16,516
Australia			8,739	11,700
Philippines	10		13,478	7,551
Colombia				5,423
Argentina				4,254
Netherlands		1,461	809	3,930
France	1,268	5,422	4,461	3,821
South Africa			2,762	3,600
Korea Rep			1,408	3,053
Mozambique			1,350	2,700
Bangladesh			361	2,475
Venezuela			2	2,466
Germany	864	1,445	1,439	1,715
UK	7,945	3,493	1,451	1,494
Sri Lanka				1,099
Uruguay		70	659	803

Table VI-1: Cassava starch imports (mt)

Country	1970	1980	1990	1995
Canada	9,661	1,192	443	716
Bel-lux	252	451	42	677
Paraguay				445
Italy	70	24	411	374
Reunion			94	249
Sweden			1,474	219
Mauritius			6	144
Mexico			152	127
Portugal			8	113
Denmark		116	6	112
Jordan			173	100
Norway			76	99
Bolivia				81
Rwanda			46	52
Gabon			243	31
Fr Polynesia		206	75	28
Spain			32	28
Macau			13	26
Chile			10	25
Ecuador				24
Switzerland			8	21
Panama			16,812	19
Trinidad Tob			3	11
Guatemala				11
Total Starch Imports	70,338	119,370	412,888	737,725

Exporters of cassava starch are more concentrated than the importer destinations, with three countries (Thailand, Indonesia and Brazil) accounting for 95 percent of world exports. Thailand, in fact, accounts for 85 percent of exported cassava starch.

Table VI-2: Cassava starch exports (mt)

Country	1980	1990	1995
Thailand	2,682	263,571	447,625
Indonesia		6,703	30,870
Brazil	925	1,690	19,164
Hong Kong			15,197
Singapore			3,231
China	2,540	1	2,650
Bel-lux	212	30	2,483
Netherlands	564	314	894
Germany	424	448	273
India			236
Malaysia	69	5	202

France	76	136	137
Paraguay			135
Colombia			75
USA		100	42
UK	326	85	18
Kenya			15
Italy	1		14
Congo, Rep			10
Total Starch	7,819	273,083	523,271

1.1. Starch Applications

Starch is used to produce such diverse products as: food, paper, textiles, adhesives, beverages, confectionary, pharmaceuticals and building materials. Some of these applications are discussed below.

Starch is used in the paper industry in four major operations: wet end applications of starch, size press applications of starch, calendar applications, and paper coatings. Wet end applications of starch increase the strength of finished paper and improve the retention of the fibres in the manufacturing process. Starches in the size press and calendar applications improve the appearance and function of the finished paper. Starch in the coating application acts as an adhesive in pigment coatings of paper.

Similar to paper, starch is used in the textile industry in three main areas: sizing, finishing and printing. Approximately 80% of the starch used in textiles is used in sizing where individual fibres of yarn must be shaped or formed into a warp that pass through a sizing solution that coats the surface of the twisted warp. The coated yarn is then heated to dry the size and a beam of warp is ready for weaving. Properties of the starch used are abrasion resistance, flexibility, be able to form a bond to the fibre, penetrate the fibre bundle to some extent, and have enough water holding capacity so that the fibre itself does not rob the size of its hydration.

Finishing is an inclusive term meaning the transformation of grey goods from the loom to a finished product that is attractive to the consuming public. It includes the process of covering blemishes or defeats that may be in the yarn. Textile printing or the impression of a design on fabric requires a carrier for the dyes and pigments and modified starches have found special uses in these applications. Printing pastes are high-viscosity mediums that preferably will not change on ageing and will resist the effect of added acids or alkalis as required by colour agents. A sharp image is required and thus a short non-stringy paste. Modified starches are frequently mixed with other industrial gums to give the required viscosity and paste characteristics.

Glass fibre sizing is a special case among textile fibres sized with starches. Starches finding use as glass fibre sizes are those with high film strength and which are incompletely cooked under normal cooking conditions, but which still form a good film. The characteristic of dispersion instability appears to be one of the more desirable properties. Thus the starch products most frequently found are cross-linked starches, corn and potato, high amylose varieties and their derivatives, as well as some cationic starches. Although most of the glass sized yarn made goes into fabric uses, a portion is used for electrical insulation and in circuit boards.

Starch is a popular base for adhesives, particularly those designed to bond paper, in some form, to itself or to other materials, such as glass, mineral wool and clay. Starch can also be used as a binder or adhesive for non-paper substances such as charcoal in charcoal briquettes, mineral wool in ceiling tiles, and ceramics before firing.

The starches most commonly used for the manufacture of adhesive pastes are maize, potato, and tapioca and of these the latter appears more suitable in several respects. Cassava starch adhesives are more viscous and smoother working. They are fluid, stable glues of neutral pH that can be easily prepared and can be combined with many synthetic resin emulsions. Corn and rice starches take a much longer time to prepare and a higher temperature to reach the same level of conversion.

In fact, for top-quality work, cassava starch is thought to be most ideal, because it is slightly greater in strength than a potato starch adhesive while being odourless and tasteless, excellent as an adhesive for postage stamps, envelope flaps and labels. Certain potato pastes have bitter tasting properties while cereal starches exhibit a cereal flavour. Adhesives from cereal starches have poor mobility and are more suitable for purposes where short parts are required for example in the manufacture of corrugated boards. Wheat starch is usually used as a thick paste in the adhesive base for bill posting and paper bag industry. The only heading where tapioca dextrin is specifically mentioned in A.E. Staley product list is under remoistenable adhesives.

Poster pastes used for billboards, wallpaper and other pasting operations that manual alignment of patterns, edges also tend to utilize high-viscosity starches. Satisfactory texture or slip properties may be achieved via cross-linking, (Wurzburg 1987) Properties required include low shear resistance or "slip" permitting the paper to be aligned precisely without losing contact with the substrate, good open time (range of tack), slow setting speed.

Gummed tape employs middle of the range viscosities. Properties required include rapid absorption of water by the dried film, high cohesive strength (tackiness) when wet, limited tendency to curl, stable re-moistening properties in the dried film, low application viscosity. To meet these requirements it is important that the starch have little or no tendency to retrograde in the dried film. Using starches low in amylose can most readily achieve this property, and/or by subjecting the starch to retrogradation inhibiting treatments on base starches such as tapioca, potato, or waxy cereal starches which is the preferred approach. (Wurzburg 1987).

A popular type of bottle labelling adhesive is the "jelly gum" made primarily from cohesive starches (root or waxy cornstarch), which have been cooked in sodium hydroxide. Properties required include the starch to be high in molecular weight, "snappy", the ability to pick up the label and anchor it to the bottle even if the bottle is wet, and "ice proof" resistant to re-solubilizing, especially in cold water.

Modified starches are used in food processing in a variety of ways. Modified starches increase the acceptability and palatability of many processed foods to consumers. Modified starches are also used to reduce costs of established food products. More expensive ingredients such as tomato solids, fruit solids, or cocoa powder can be extended with combinations of modified food starches, flavours, and other inexpensive food substances. Modified starches and dextrins have successfully replaced caseinates in meat emulsions, coffee whiteners, and imitation cheeses. Modified dextrins are also used to replace butterfat in ice cream and ice milk, vegetable oil in salad dressings and shortening in icings. Modified food starches and dextrins play a very important role in cost reduction efforts.

Case Study: North America

Daphne S. Taylor

In 1997 the U.S. imported 13,551 metric tons of cassava starch and 6,889 metric tons of tapioca starch. In Canada 1,771 metric tons of cassava starch and 1,043 metric tons of tapioca starch were imported. Other imported starches into the U.S. in 1997 are presented in Table VI-3.

Table VI-3: U.S. Imports of Starch, 1997

Imports	Quantity (MT)	Value ('000$)	$/kg
Wheat starch	1,136	767	.68
Corn starch	3,815	3,080	.81
Cassava starch	20,440	7,737	.38
Potato starch	25,273	11,796	.47

Source: (Sunderland 1997)

This level of cassava starch import is dwarfed by the size of the U.S. corn refining industry that produced 2.7 million metric tons of cornstarch in 1997. The U.S. corn refining industry in 1997, representing 20% of total corn use, utilized over 46 million metric tons of corn. Approximately a third of the corn used by refiners goes into high fructose corn syrup production. Another third goes into fuel alcohol (ethanol). A final third goes into starch sweeteners (glucose and dextrose) and cornstarch Table VI-4.

Although cassava starch imports are quite small today, this was not always the case. Cassava was the main source of amylopectin starch in the U.S. until World War II when the Japanese severed supply lines and forced processors to turn to waxy corn. Waxy corn found in China in the early 1900s was introduced into the U.S. in 1909 but remained a curiosity until the mid-1930s. In the early 1940s work at the Iowa Agricultural Experiment Station revealed that the amylopectin starch from waxy corn had properties similar to tapioca starch (International Starch Institute).

Table VI-4: Corn use and product shipped by U.S. Corn Refiners, 1997

	Corn Use mmt		Shipments of Product mmt	
HFCS	13.70	30%	10.14	59%
Glucose/Dextrose	6.35	14%	4.38	25%
Starch	6.09	13%	2.70	16%
Starch & Starch Sugars	*26.14*	*57%*	*17.29*	*100%*
Fuel Alcohol	13.08	28%		
Beverage Alcohol	3.38	7%		
Cereal & Other	3.45	8%		
Food and Industrial	*46.05*	*100%*		

Source: USDA ERS

The chemical structure of starch consists of two major polymers, amylose and amylopectin. The level of each varies depending upon the starch source. Most starches such as regular corn and wheat contain about 28% amylose while potato and tapioca contain about 18% amylose. Waxy corn contains practically no amylose while high amylose corn may contain up to 70% amylose.

Owing to difficulties in importing tapioca from the Far East during World War II, the commercial production of waxy corn was begun. By the 1960's, waxy corn use was established and the use of cassava starch in North American began its decline. In Figure VI-1 imports from 1961 to 1997 are illustrated as reported by the FAO trade statistics.

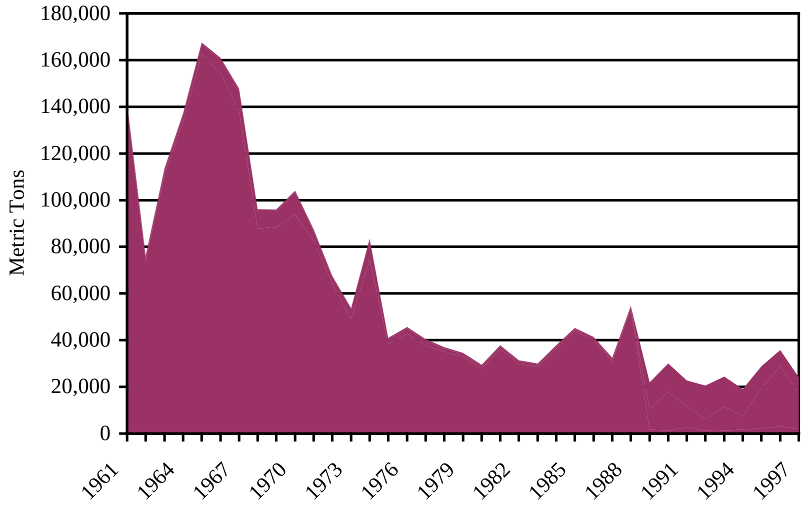

Figure VI-1: North American imports of cassava starch

Today commercial waxy corn for industrial utilisation is produced under contract to large wet milling companies such as National Starch & Chemical Company, A.E. Staley Company and American Maize Products. Waxy Corn is produced in only a few counties in Iowa, Illinois and Indiana and accounts for about a half million acres or 0.6 percent of total planted corn acreage in the U.S. (Crookson 1979).

To meet the future needs of their consumers, refiners continue to actively invest and support waxy corn breeding programs and production (National Corn Growers Association). Contract agreements between refiners and farmers specify certain grain quality standards and waxy purity requirements. Variations in the amylopectin components can result in failures by the wet milling processor to meet specific standards of the processed starch. Therefore, premiums are paid to the waxy grain producers by the wet miller to compensate for the extra quality control procedures that must be followed. Typically waxy corn commands a premium price (~25-30 cents/bushel) above U.S. No. 2 yellow corn prices (Fergason 1994).

Another important development for the wet corn milling industry was the development in 1961 of a process for enzymatically converting glucose to fructose. Sweetness equal to sucrose was achieved with the introduction of a High Fructose Corn Syrup (HFCS) containing 55% fructose and 45% glucose in the late 1970s. Acceptance of this product for soft drinks accelerated production of HFCS in the early 1980s and in 1985 consumption of corn sweeteners for the first time exceeded sucrose consumption in the US (Figure VI-2). As can be seen from Figure VI-3 the price for sugar/dextrose and HFCS is generally higher than the price of cornstarch.

Today the major markets for sweeteners are nearly saturated making their prices highly competitive. This was apparent in 1995 when rising corn prices were passed along to higher starch prices but not to the price of HFCS and

Dextrose sweeteners. Higher corn prices, at over 3 dollars a bushel, gave a boost to cassava starch imports in 1996 (Figure VI-4).

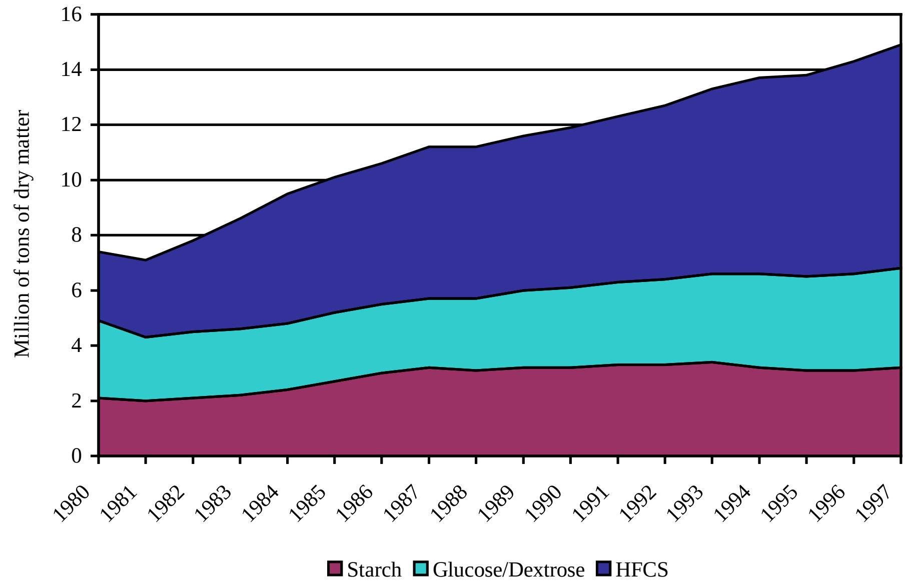

Figure VI-2: Amount of corn used to produce different "starch" products

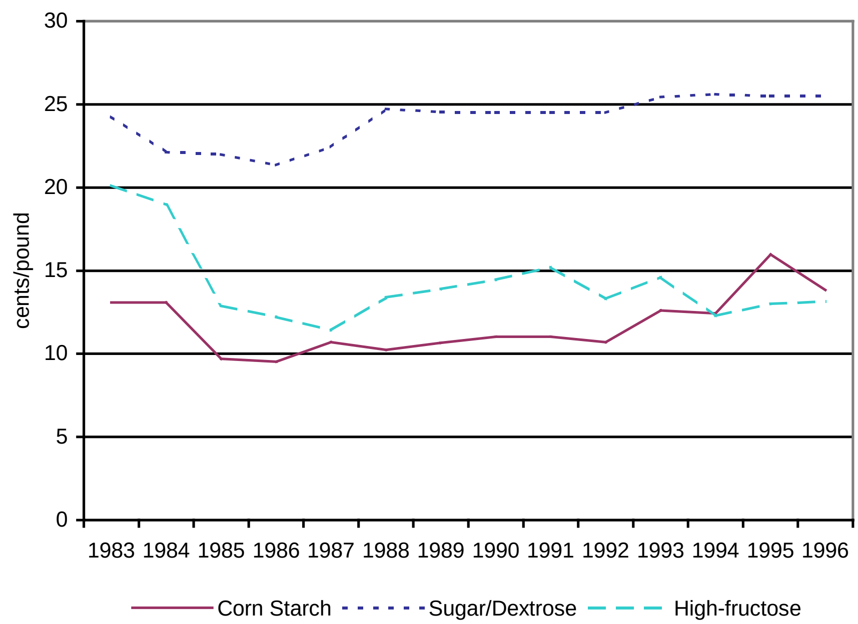

Figure VI-3:Price of different starch products

Cassava starch use is highly dependent on the stability of U.S. corn production and the U.S. economy. National Starch and Chemical, for example, has been plagued by exposure to volatile raw corn and paper markets since 1990. The company had increased prices moderately throughout the 1980s to support market development, service and research and development teams. In 1990 as the recession hit and volatile corn markets began, National had to cut its prices, decrease its research and development and cut staff. To maintain position, product lines were shifted away from the paper industry toward the food industry with larger and more predictable profit margins. As a result, cassava and cassava-blended starches have become more important to National (Watson 1988). The paper industry responded by shifting away from more expensive and higher quality waxy maize and potato starches to less expensive dent corn.

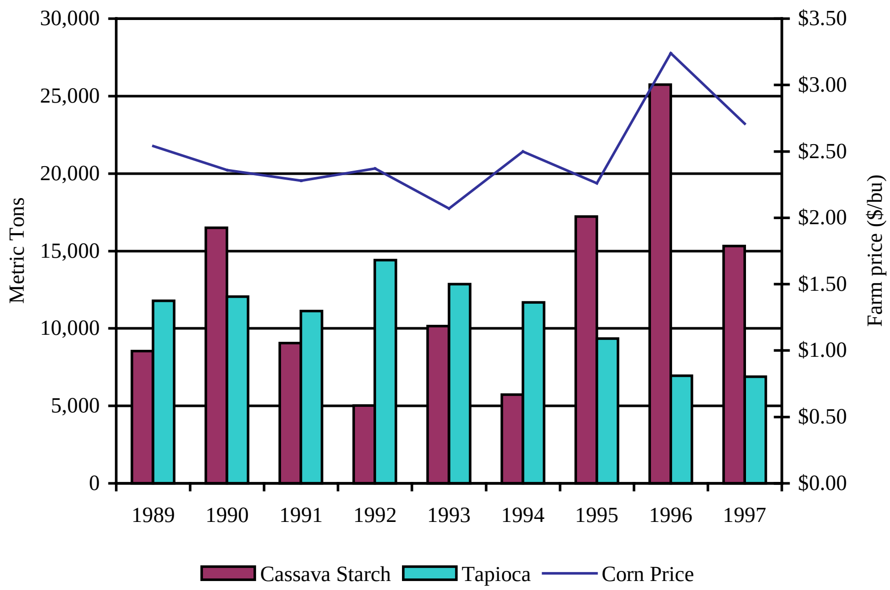

Figure VI-4: Relationship between corn prices and starch imports

Starch and starch products are used in a variety of ways in many food and manufacturing industries. Industrial use accounts for approximately 75% of starch consumption while food use accounts for 25%. Of the industrial uses, the paper and corrugated box manufacturing industry uses about 80% of the industrial starch supply, followed by textiles, adhesives and other industries. Details of the industries that use starch in their manufacturing by SIC code will be published on the Global Cassava Strategy web site. Appendix VI-1 describes briefly starch applications.

An example of a large user of industrial starch in the U.S. is the paper industry. In fact, the U.S. is the world's largest producer of paper and allied products with a 180 million metric ton capacity, 162 million metric ton production and 167 million metric ton demand Table VI - 5.

Table VI-5: North American capacity of paper industry, million metric tons 1996

	U.S. Domestic			Canada Domestic		
	Capacity	Production	Demand	Capacity	Production	Demand
Paper & paperboard	90	81	83	20	18	6
Newsprint	6	6	11	10	9	1
Printing & Writing Paper	24	21	24	5	5	2
Other Papers & Boards	60	54	49	5	5	4
Total	180	162	167	40	37	13

As paper and paper products demand grows in North America so will the demand for starch. Currently the total volume of industrial starches consumed in paper and paperboard mills in North America is about 1.3 million metric tons at industry capacity.

World demand for paper has doubled in the past 20 years and is forecast to double again by the year 2010. The annual consumption growth rate for paper and board over the next 15 years is expected to be 3.2 percent (2.5 in developed countries and 5.5 in developing countries) (Canadian Pulp and Paper Assocation). In North America, printing and writing paper grew at a rate of 7% annually in Canada and 3% in the U.S. between 1980 and 1996 (Table I-6). The reduction and removal of trade barriers will also positively affect export growth in North America in the future. Canada for example, recently won an agreement from the European Union for the early phase-out of tariffs on many Canadian paper grades. In the year 2000 the EU tariff on many non-newsprint grades and in 2002 the tariff on newsprint will be phased out.

Table VI-6: Growth Rates in Production 1980-1996

	Paper & Paper Board	Newsprint	Printing & Writing Papers	Other Papers & Boards
Canada	1.98%	0.28%	7.35%	2.17%
US	2.47%	2.51%	3.21%	2.20%
World	3.35%*	2.02%	4.99%*	2.89%*

Source: (Paperfo) *1980-1994

One of the greatest areas of growth for starch of late has been in the use of wet-end starches primarily cationic corn and potato starch. The total wet-end starch market is currently valued at 230-250 million dollars or 238,000 metric tons and is expected to grow 10% or more annually. The reason for the increased starch use is the increased use of alkaline paper making techniques. Alkaline papermaking has been in use for over 30 years in Europe but has only recently been adopted in North America. As inexpensive filler loadings increase, the loss in strength is made up for by additional starch use, saving mills $15 to $70 a ton depending on the paper grade. (Wurzburg 1987)

A second growth area has been in the use of surface sizing, a high volume consumer of pearl and pre-converted starches. Almost 909,000 metric tons of unmodified and modified starches were used in size presses of late. This starch use has grown because of the increased volume of paper capacity introduced since 1990. Almost 1.5 million tons of uncoated freesheet capacity was added, all of it using starch as a primary surface-sizing component.

A third area of growth is at the size press where more innovative equipment is being installed that applies a film of cationic starch making paper perform like a coated matte No.3 grade and challenging fully coated paper mills. Starch use in coating paper and board is flat or declining of late. Starch has lost market share to latex because of latex's ability to provide optical properties like gloss. Starch has also lost to protein in board coatings because of protein's ability to promote wet-end strength in carrier stock. Starch consumption used in lightweight coated has grown with new capacity but as quality rises, starch use declines (Paperfo).

Among the board mills, National Starch and Chemical is the starch leader. Staley and Penford are equal leaders in the paper market. Penford Gums and Ethylex are equal leaders in surface sizing applications.

Another user of starch is the food and beverage industry. The plant sources for modified food starches in North America are predominately corn, potato and tapioca. Four corn varieties are used: dent corn, waxy corn, and two varieties of high amylose corn. Cassava starch is used to a much lesser extent than corn, but its importance as a source of modified food starches is growing rapidly. Unmodified starches are widely used in the bakery industry. But have limited resistance to the physical conditions applied in modern baking and industrial heating processes. It is modified waxy maize and cassava starches that are increasingly being used to produce a large number of cross-linked and substituted food starches used in modern baking and industrial heating processes. A description of the allowable food starch modifications as outlined by the Food and Drug Administration's Code of Federal Regulations is provided in Appendix VI-2. Confectionery manufacturers and fruit and vegetable processors account for one-third of the food industry starch consumption, followed by bakeries, biscuit manufacturers and other food processors.

Growth opportunities for the development of cassava starch in North America are limited because of the preference and availability of locally produced starch sources. This disadvantage is heightened by the ability of chemists to create specialized starches. The close co-operation between the end users of starch and starch manufacturers in the development of specific starch products means that outsiders have little opportunity to know the *new* modifications that are required until after the modified starch has been used. Imported modified starches are usually produced through a joint venture or agreement with a North American company (see Chapter III of the Thai experience with the development of modified starches).

Growth opportunities for cassava starch in North America are further restricted, owing to the co-operation between the U.S. and Canadian governments and domestic corn producers and processors. One example of such co-operation is the “Plant/Crop-Based Renewable Resources 2020” agreement between the U.S. Department of Agriculture, agricultural producers’ groups and the U.S. Department of Energy. The purpose of the agreement is to stimulate research and development of new products made from agricultural commodities such as corn, wheat and soybeans. This research is to be aimed at finding new ways to use crops, trees, other plant material and agricultural wastes to manufacture products such as plastics, paints and adhesives. The agreement is in effect for two years with a budget of approximately $100 million, and may be extended (Canadian Pulp and Paper Association).

The starch industry is a very vibrant and exciting industry. Starches are highly substitutable, but cassava starch does have properties of clarity, viscosity and cold temperature that give it a competitive edge. Nevertheless, price and location are the prime factors that determine the demand of various starches and their bases (see the following section on the European starch market).

The demand for starch in North America is driven by the demands for final products that use starch in their production process. The nature of this demand means that starch suppliers, especially non-North American suppliers, have a very limited ability to develop and expand their product markets. Exporters of cassava starch can extol the virtues of their product, but their main function is to provide, when requested, the appropriate quality of starch at the correct time, with a competitive price.

The quality and technology required to produce starches varies from industry to industry. At the risk of oversimplifying the industry it can be said that the glue and plywood industries use starches that are the easiest to produce and have the least restrictive specifications. For these uses price is the prime determinant of which starch is used. The paper and textile industry require a higher quality of starch with modified starch being required for a number of operations. For these uses price and specifications become more important as determinants of competitiveness. The food industry requires the highest quality. For this industry the starch often times has to be *designed* for specific uses.

The North American demand for cassava starch will probably grow proportionally with the starch industry through joint ventures and partnerships between North American companies and cassava producing countries. An additional and perhaps more important benefit for the developing countries of these joint ventures may be the expanded use of cassava and modified cassava starches domestically.

For development of the cassava starch market the key stakeholders are exporters and importers of cassava starch, wet corn milling producers, starch end users, corn producers, and government. The North American stakeholders are the most influential and powerful. Their sheer size and ability to influence creates a barrier to new entrants. In many of the starch consuming industries only one or two companies dominate their industry.

Case Study: Europe

Guy Henry

Cassava starch imports constitute a very small share of the total EU starch utilisation, but there is an increasing diversification of European starch companies in joint ventures exploring cassava as an alternative starch source, especially in SE-Asia[18]. In this section, more light is shed on the dynamics of the EU starch industry and the principal factors that influence its future. Hence, the discussion focuses on the starches that compete with cassava rather than cassava starch itself.

EU starch production is estimated at 7.1-7.3 mmt, processed from a variety of sources such as wheat (21%), maize (33%) and potato (46%). Raw materials are rarely imported because of prohibitive levies. In some cases, there may be reduced levy regulations (as in Spain and Portugal) or applications for Inward Processing Relief (IPR) which is a mechanism to import raw materials (not applying to wheat) at "competitive" prices, when domestic harvests are insufficient to supply the industry. Furthermore, refunds are a key factor for processor's competitiveness, when EU grain prices are above world price levels. Some of the major starch factories are "mixed plants", relying on two different starch sources, wheat and maize (AAC, 1997).

The 4 largest companies, Cerestar, Roquette, Amylum and Avebe, together produce almost 80% of total EU starches. These companies are quite different in history, ownership and specialization. For example, Cerestar is more specialized in glucose syrups, while Roquette has the market edge for polyhydric alcohols, and Amylum is a market leader with HFS. Avebe is largely potato sourced and is becoming particularly strong in specialized starches for non-food industries, while traditionally catering to paper and food-industries. Most of these companies operate factories in several European countries (in addition to having shared processing interests in Asia and the Americas). Compared to the US, the European starch companies are more diversified in both source bases and product portfolio, but on average have significantly smaller installed capacity or plant scale.

EU starch by product group is made up of, starch sweeteners (51%), native starches (27.5%) and modified starches (21.5%). Some sources make the rough distinction of starches versus fermentation products. However, from a market and policy point of view, the important distinction is, starches for food or non-food usage. EU starch can be grouped as: Food use (12%), Non-food

[18] See the Phase I report for more detailed information (Henry, Westby, and Collinson 1998)

use (41%), Ethanol (3%), HFS[19] (4%) and Other sweeteners (40%) (Henry, Westby, and Collinson 1998). Compared to the US, the EU food and non-food shares are significantly larger, while the HFS and ethanol shares are significantly smaller.

By utilisation industry this is divided into:

Sweets and drinks:	*33-34%*
Processed foods:	*21-22%*
Pharma and chemicals:	*15-16%*
Paper and corrugating:	*27-28%*
Feed:	*2%*

The EU's HFS industry is subject to rigorous government interventions, most importantly through the allocation by country and company of annual production quotas. These quotas can only change when a country becomes a new member of the EU, bringing in an additional quota. These regulations basically protect the EU domestic sugar industry, but have put a ceiling to the HFS industry development in the EU. The EU's HFS world market share is estimated at 3%, while the US maintains a 75% share. World HFS production, at a current estimated 10 mmt, has been growing at an average 5% per year (USDA-ERS, 1998). While the US seems to have an installed over-capacity, the EU may have a potential under-capacity. HFS's principal demand comes from the soft drinks industry.

While ethanol production in the US is strongly subsidised, in the EU, very few advantageous government interventions exist for ethanol production, although it is known that approximately 40% of total EU starch production benefits from "production refunds". The subsidy absence for ethanol, according to experts, is the main reason for the small size of this product output.

Modified (chemically) starches for non-food use theoretically enjoy a system of refunds for compensation of high-prized internal raw material purchases, while selling in relatively unprotected markets. These interventions have led to a relative rapid growth of the sub-sector, since 1985. But, according to AAC (1997), the "production refund" is not sufficient to ensure supplies at world market levels. This starch industry is facing serious difficulties from cheaper imports, particularly with the bio-chemical industry. As a result, margins have diminished to such an extent that certain starch producers have switched sales away from the bio-chemical industry to the food sector. Cheaper bio-chemical product imports are possible because the EU starch (hydrolysates) industry lacks economies of scale and suffers from much higher (than the US) operating costs (AAC, 1997).

[19] While in the EU, HFS (high fructose syrup) is also called "isoglucose", in the US, it is named HFCS (high fructose corn syrup), because of its unique source base, corn.

On the other hand, in the food sector, EU starch products can be priced on the basis of their functionality because the finished products of this sector are properly protected from imports (AAC, 1997).

The above discussion already has implicitly shown several indications of future growth. Because of domestic sugar industry protectionism, the HFS industry has a very limited growth. Ethanol production, on the other hand, does not enjoy any significant subsidies, as is the case with some of the other starch or fermentation products, and hence its market and market growth seemed limited. However, one can argue that in the longer run, more attention may be paid, in Europe, to more environmental friendly fuels, which may then benefit the ethanol industry.

If Europe would follow similar industrial product developments as in the US, future lysine and citric acid demand would continue to strengthen (USDA-ERS, 1998). But on the other hand, if US capacity would increase, citric acid imports from the EU would decrease, putting further pressure on internal EU markets.

Table VI-7 shows a strong growth rate for starches for food use, because of further increased product technology advances, beneficial subsidies/refunds and the relative competitiveness problems in the non-food sector.

One important phenomenon that needs to be discussed here is the recent shift from maize to wheat as a source crop for EU starch. According to the AAC, over the last 5 years the share of wheat rose from 23% to 35% in the EU starch industry, almost surpassing the share of maize. The main reason has been cost reduction opportunities, because of the premium of wheat by-products, especially high-valued wheat gluten. As such, wheat has become the relative cheaper starch source in the EU.

Table VI-7: Expected future production growth of selected starches in the EU

Starch Market	Trend
Lysine + citric acids	***
Starches for food use	***
Other sweeteners	**
Starches for non-food use	*
HFS (isoglucose)	-
Ethanol	-

Note: *** high; ** intermediate; * low; - flat

Without a doubt, the future of the EU starch industry will be influenced by the continuing changes of CAP and WTO trade policies. As expected, internal grain prices will be further reduced, but this may be offset by the further reduction of import tariff levels, which in turn will benefit US and Asian exports to the EU. During the 28 October 1997 meeting of the AAC[20] this was reflected in a statement

"In order to safeguard the competitiveness of the EU industry, the high structural industrial costs[21] in the EU should be taken into account during the next WTO trade negotiations. The EU should therefore negotiate a border protection for starchy products, as long as the high structural costs generated by EU policies have not been harmonized" (AAC, 1997).

Given the current characteristics and dynamics of the EU starch industry, there are basically 2 windows of opportunity for cassava starches to increase its EU market share: (a) in the same product markets at lower prices, and (b) in niche markets.

(a) Same product markets, at more competitive prices:

As is shown in Henry (Henry, Westby, and Collinson 1998) and further in this report, traditionally, almost the entire traded cassava starch volume has originated from SE-Asia, and in particular from Thailand. Currently only a small volume of cassava starch is imported into the EU, mainly owing to prohibitive import tariffs. Nonetheless, as was noted in the earlier report, in 1996, Thailand exported double the volume that it is officially allotted (10,000 mt at preferential tariff rate of 150 ECU/mt), at the higher tariff rate (260 ECU/mt) and was still competitive. If, on the one hand, Thai cassava starch costs could be further reduced, and on the other hand, WTO-regulations would further reduce EU tariffs, as is expected, cassava starches could increasingly compete with EU starches. Table VI-8 compares various world prices of commonly traded starches, showing the competitive price of cassava starch.

However, if one could compare the social costs versus the private costs of the US, EU, SE-Asian and Latin-American starch manufacturing, it would be very obvious that the current US and EU starch competitiveness and subsequent world market shares, are to a large extent due to an extensive and complex array of domestic policy measures, mostly being direct and indirect subsidies, intervention prices, import tariffs and quotas and export refunds. If the expectation comes true that future WTO trade negotiations will further reduce international barriers to trade, EU and US starch industry competitiveness will be reduced, directly benefiting the market positions of Asian (and Latin) cassava starch products.

[20] L'Association des Amidons et des Cereales, the association of EU's starch and fermentation industries, based in Bruxelles.

[21] The starch industry argues that because of EU policies, the industry's structural costs are significantly higher than in the US, being its principal competitor. Furthermore, energy, transport and social costs are much lower in the US. In other countries (Latin America and Asia), these are even lower, in addition, labor and environmental costs are minimal, while health and safety standards are missing (AAC, 1997).

Table VI-8: Selected world market starch prices, 1996-98 (CIF US ports, US$/100KG)

	III-96	IV-96	I-97	II-97	III-97	IV-97	I-98
US Corn starch F-U	59.0	68.0	70.7	74.0	79.3	75.4	75.0
US Corn starch non F-U	46.0	43.0	44.3	43.7	43.0	46.8	42.0
US corn starch, native	41.4	33.0	28.4	29.8	29.3	30.5	30.2
EU Potato starch F-U	49.7	49.3	48.3	48.3	46.7	43.5	43.0
EU Potato starch non F-U	48.0	43.3	39.3	40.7	32.7	39.3	32.0
EU Wheat starch F-U	72.0	64.3	72.3	78.3	59.3	57.5	52.0
EU Wheat starch non F-U	35.0	33.3	37.3	40.4	33.3	35.3	36.0
Thai Cassava starch, native	35.3	35.7	34.7	34.3	29.0	29.6	32.0

Note: F-U = food use

Source: Adapted from LMC International

The other major argument regards raw materials. Whereas, US and EU corn, potato and wheat production are nearing optimal yield ceilings, cassava production, for example in Thailand, is still at a very low level of technology, yielding average outputs of 13-14 mt/ha. As demonstrated by Henry and Gottret, Thai cassava yields can potentially be more than doubled[22], with current technological advances such as improved varieties, soil/plant management and cultural practices (Henry and Gottret 1996). Hence, the potential for cassava production to advance and consequently reduce per unit costs is far greater, than for US and EU starch sources. In time, this will be one of the most important factors underlying improved cassava starch market competitiveness.

One aspect that needs further discussion is the issue of starch processing by-products. Corn and wheat starch processing generate high-valued by-products in the form of gluten, bran, fibre, and germ. Cassava and potato starch processing by-products are of low quality and value. Moreover, liquid cassava processing waste requires a costly process for recycling. Hence, the starch processing cost comparison becomes highly complicated when taking into account the cost and benefits of its by-products. Table VI-9 attempts to compare the various starch production, processing and market factors in a qualitative perspective.

[22] It was reported in 1998 that 20 to 30 percent of cassava area is now planted to Rayon 90 and KU50 which is yielding 29 tonnes/ha (personal discussions with TTTDI June 1998).

Table VI-9: Qualitative comparison of starch parameters

	maize	wheat	potato	w-maize	cassava
Raw material productivity	***	***	***	***	*
Raw material price competitiveness	***	**	*	***	***
Starch conversion efficiency	***	**	*	***	**
Value of by-products	**	***	*	**	*
Cost of waste disposal	*	*	**	*	***
Starch price competitiveness	***	**	*	**	***
Food industry application	**	**	***	***	***
Non-food industry application	***	***	**	**	**
Sweeteners application	***	**	*	***	**
R&D advances	***	***	***	***	*

Note: *** high; ** intermediate; * low

(b) Niche markets:

Cassava starches incorporate various intrinsic characteristics or functional properties, especially with respect to grain-based starches, that translate into relative comparative advantages for further processing. It needs to be stressed that most of these advantages are not absolute, since grain-based starches after additional manipulations could acquire similar characteristics, at an additional cost. The key therefore, is that the basic cassava starch without additional manipulation or modification incorporates these special functionalities. Cassava starch state of the art R&D includes the following main special characteristics that enjoy premiums, especially in food industries, and to a lesser extent in other non-food industries, such as in the pharmaceutical industry: high transparency and high suitability for ready cooked foods, sauces; high resistance to acidity and good applicability for acid-based sauces, jams, etc.; high viscosity which is applicable for desserts, puddings, soups, fillings, gums; and a high purity, absence of gluten, phosphate, oil, fat and proteins, all of which are highly desirable for low-fat diet foods, foods without gluten, and anti-allergic diets.

Extensive cassava product development research in Thailand demonstrated that when comparing the suitability and/or performance of potato, corn, wheat, cassava and waxy maize starches in the manufacturing of a wide range of food product groups, cassava starch rated second best, after potato starch. The ratings for the starches were 42, 21, 21, 34 and 32, respectively (Maneepun 1997). If the higher price of potato starch is taken into account (see Table VI-6), the competitiveness of cassava starch is very strong. However, relative comparative functional property advantages can be eroded by technology advancement. At the same time R&D can further develop cassava opportunities. Stockli and Rieder (1997) argue that modern biotechnology could generate genetically engineered cassava that would have excellent properties for the manufacturing of, for example, cheap thermo-bioplastics.

An additional indirect effect of these special characteristics is the implication regarding certain barriers to trade. In most countries, there exist different import regulations for native and modified starches. The latter being higher value added and subsequently higher taxes. Hence, a native cassava starch, embodying characteristics of a modified starch, will be taxed at the lower native starch, import tax rate. This translates into significant discounts for the food processing industry. Besides the economic impact of this, there are also additional environmental consequences, since native cassava starch will be a “natural product” which is more wholesome, contrary to modified starches.

Two principal marketing strategies for cassava starch development to improve its EU market share are proposed. The implementation of these strategies, however will take considerable additional investments and very astute decision-making, organisation and management. The first requirement, that of a significant financial outlay, will come at a difficult moment, as current financial conditions in SE-Asia have taken a major downward turn, reducing investors’ confidence and the availability (and terms) for additional credit lines. Further integration through joint ventures with foreign (European or US) investors will be most essential. This may not only facilitate much needed capital, but will also significantly improve marketing capacity and product distribution networks, which are essential to successfully penetrate and capture EU existing and/or new product markets.

Furthermore, are Asian cassava starch producers sufficiently ready and organized to face the corporate culture conditions facilitating price-fixing and the oligopolistic nature of the industry, as mentioned by Sansavini and Verzoni (1998) discussing the ADM price-fixing scandals in the lysine and citric acid industries? Increased joint ventures, both at the processing and marketing level, again, will be vital for survival.

The constraints and/or opportunities that exist to realise the potential for cassava starches to capture increased product market shares in EU markets can be discussed from both the supply and demand side. On the supply-side, factors include:

Government interventions: Both the US and the EU enjoy a variety of direct and indirect government subsidies, whereas SE-Asian producers and processors have little or no subsidies at all. As earlier mentioned, some 40% of total EU starch output benefits from production refunds. The EU farm and industry lobby is extremely strong, opposing any policy changes that will reduce profit margins.

Reduced processing costs: While the number of Thai starch factories has decreased significantly, industry output continues to rise, further vertical integration and economies of scale (plant size) in processing are needed, as proven to be one of the keys to success in the US.

Reduction of per unit cassava root costs: Cassava yields are still too low, the same as average cassava root starch levels. Furthermore, root availability throughout the year needs to be improved. Further integration of the industry may diminish cassava root price fluctuations.

Low valued by-products of cassava starch manufacturing: Cassava (and potato) starch processing do not benefit from the generation of high-value by-products (as is the case for the grains). Hence, further R&D is needed for finding ways to add value to cassava by-products. This implies additional pressure on the reduction of production costs.

Additional cassava product development research: Public and private starch product research investments for cassava are negligible compared to grain and potato based starch R&D. This offers an opportunity to further advance the potential that cassava starches have.

Industry organisation: The starch industry organisation in SE-Asia or Latin America is sub-optimal compared to the US and the EU. In Thailand 5 tapioca organisations exist, that could be collapsed into one. In China, there exist provincial starch associations, but these lack funds, structure and organisation. The Brazilian starch producers' organisation, ABAM, exists, but lacks, members, power and organisation. Industry and technology information is lacking. Vertical integration between farmers and processors is sub-optimal.

On the demand and market-side, factors include:

Government policies: EU import tariffs and quotas have been seriously constraining cassava starch imports. Although expectations are that the next WTO trade round will further liberalise trade, the EU starch industry lobby is extremely strong (AAC, 1998).

Market and marketing tools: While the Thai starch industry-marketing services seem to be quite efficient, this is not the case for other cassava starch producing countries. Especially, quality market information is lacking.

Cassava publicity: There are still many misconceptions and absence of knowledge about cassava and its potential. This regards both the public and private sectors. Increased publicity, advertising the commercial applications of cassava starches (and other products) could boost interest, which could be translated into strengthened demand.

In the previous discussion of cassava starch’s potential to capture an increased share of the EU starch market, it has become clear that, first, several viable opportunities do exist, but second, a range of considerable bottlenecks need to be resolved, in order to fully realise this potential. The major stakeholders key to this development belong to both private and public sectors. Most important is future actions should come from an integrated effort between these sectors to generate the maximum impact.

Private sector: There is a need by the cassava starch industry, as well as the EU starch industry, to further joint ventures and additional investments that increase processing, economies of scale and marketing. They also need to formulate a development strategy integrated with the public sector and policy makers.

Producer, processor & export organisations: Increased effort is needed to organize and reorganize and/or streamline these associations, for increased effectiveness and performance. Further vertical integration of the industry is a major requirement.

R&D and Extension institutions: In combination with the private sector, research and development and extension institutions need to accelerate applied cassava product development research and the development and transfer of productivity enhancing and cost reducing technologies.

European Commission and EU policy agencies: Need to be cognisant that the benefits realized by the EU starch industry impose large social and private costs to cassava producing LDC countries.

National government finance & policy agencies: Need to be full shareholders of the development efforts, together with the private sector and R&D institutions. Possibilities of policy interventions to help in this effort need to be evaluated.

The EU starch industry is a sophisticated, high-tech, large and powerful industry. While traditionally, maize and potato were the major starch source crop, in recent years, wheat has become increasingly important, and is currently the cheapest starch source crop. Furthermore, during the last 10 years, EU starch factories have increasingly invested in Asian cassava based starch industries. The EU starch industry is highly diversified and its competitiveness at home and abroad, depends to a major extent on EU policy mechanisms and their developments. Cassava starch has the potential to capture increased EU market share, but this will require considerable future outlays of capital in cassava production, processing, marketing and industry organization. Two main windows of opportunity exist, competing by further cost reduction, and competing in special niche markets. A further integration with EU based starch companies will be beneficial. The major stakeholders include both private and public sectors. The current financial downturn of Asian economies may slow down this development process in the short term, although at the same time, Asian cassava products will become relatively cheaper.

Conclusions

This section has highlighted the diversity of uses for starch, and that cassava starch has some inherent properties that are demanded by some industries. These properties are perhaps most important in the adhesives and food industries. The preferred properties of cassava starch include:

High transparency: high suitability for ready cooked foods, sauces,

High resistance to acidity: good applicability for acid-based sauces, jams

High viscosity: applicable for desserts, puddings, soups, fillings, gums

High degree of remoistenablity: applicable for postage stamps, flaps and labels

High level of amylopectin: a property duplicated by waxy corn, and

High purity: highly desirable for low-fat diet foods, foods without gluten, anti-allergic diets because of the absence of gluten, phosphate, oil, fat and proteins.

However it was shown that an alternative starch could almost always replace cassava starch if it is a lower cost option. Unfortunately this is not quite a reversible situation, because even low priced cassava starch may not be able to overcome the strong links that exist between producers, starch manufactures and producers of final products that utilize starch in Europe and North America. Also the research effort to develop and utilize cassava starches is minuscule when compared to the R&D efforts devoted to maize, potato and wheat starches.

Nevertheless there are a number of events that promote further development of the export market for cassava starch. Firstly, there is the increasing number of alliances between starch producers in Europe and North America and cassava starch producers in Southeast Asia. Secondly, reductions in price protection, and subsidies in Europe and North America would appear to make cassava starch relatively more price competitive. Thirdly, an increasing awareness of the availability of cassava starch has been accompanied with increasing interest in possible ways of using cassava starch. Finally, the industrial demand for sectors of the economy that use starch, as an intermediate good, is expected to continue to grow at least 2.5 percent.

Cassava starch while being an imported starch (50 thousand plus tonnes imported into the North America and Europe) is dwarfed by the 17.3 million tonnes of starch and starch sugars produced in the US, or the 7.7 million tonnes produced in Europe. Clearly a small increase in market share for cassava starch exports will have a significant impact for exporters without greatly changing the situation of North American and European starch producers. These potential gains provide reason for continuing to try and develop the export market for cassava starch

Chapter VII: Cassava Chips

Global Opportunities

Truman P. Phillips and Guy Henry

Interest in the use of cassava as an animal feed dates to the creation of the European Common Market and its Common Agricultural Policy. This policy, designed to promote and protect member country agriculture, favoured the blending of protein rich feeds, such as soybeans, with energy rich feeds, such as cassava, to produce animal feeds. European feed compounders sought sources of cheap cassava - first in the form of chips and later in the form of pellets. The growth in this market has been impressive (Tables VII-1 and 2). In 1995 11 countries imported more that 10,000 tonnes of dried cassava (which is basically chips and pellets) and 6 cassava-producing countries exported more than 10,000 tonnes. The non-European importers have been China, Korea, the U.S.A. and Japan, all of which became cassava importers after 1980.

Table VII-1: Dried cassava imports (mt)

Country	1961	1965	1970	1980	1990	1995
Netherland	141	72,093	502,166	2,491,590	4,600,769	1,107,308
Spain		10,939	10,707	336	769,760	658,890
China					703,711	457,317
Bel-lux	22,185	95,925	268,423	822,330	935,324	393,371
Portugal	10,370	10,644	2,737	595	536,962	324,244
Korea Rep					763,465	152,061
Germany	37,383	387,962	587,645	1,354,695	773,461	119,093
Italy			13,948	98,970	71,834	74,489
France	26,350	17,400	11,088	365,072	468,233	68,509
USA					179,000	24,052
Japan	8,255	2,949		3	220,935	16,317
Totals	104,684	597,912	1,396,714	5,133,591	10,023,454	3,395,651

Over time different European countries have been the lead importers, only one country, Thailand has been the lead exporter. The data in Table VII-2 confirms what has already been presented graphically. The data also show the sharp decline in the demand for cassava that occurred between 1990 and 1995. Imports declined by more than 6.6 million tonnes. European imports declining by 5.4 million tonnes. It is interesting to note that the Thai exports of dried cassava dropped to only 4.3 million tonnes, owing to their ability to find non-European markets for cassava.

The data does confirm the great success that Thailand has had in this market. The Thai success as the major supplier is briefly described later in this chapter. Suffice it to say that the animal feed market grew to be a very important cassava market for Thailand.

Table VII-2: Dried cassava exports (mt)

Country	1961	1965	1970	1980	1990	1995
Thailand	8,405	400,526	1,172,100	4,970,420	7,557,577	3,224,191
Indonesia	8,719	84,210	334,227	386,055	1,271,101	481,483
Netherland	4	372	26,296	333,056	259,154	156,507
Bel-lux	13		1,163	201,453	58,978	75,594
Costa Rica		2	69	6,676	16,000	44,926
Germany	42	19	260	18,250	46,348	38,847
Viet Nam					28,000	30,500
Tanzania	19,217	8,252	8,554		35,000	21,000
Total	36,400	493,381	1,542,669	5,915,910	9,272,158	4,073,048

Historic and current European cassava imports for animal feed usage have been discussed, in detail, in the Phase I study (Henry, Westby, and Collinson 1998). The latest inside information from major European and Thai cassava pellet/chip traders further emphasizes cassava's bleak future. While 1997 Thai pellet exports to the EU amounted to 3.3 mmt, valued at 8,394 million Baht, the expectations for 1998 are down to 3.0 mmt for a value of 7,875 million Baht (TTTA 1998). This may be somewhat too pessimistic, since the relatively cheaper Baht may offset reduced exports. Nonetheless, cassava pellet imports from Thailand and Indonesia are steadily decreasing. Some of the main reasons for this phenomena are reduced price levels of competing EU feed grains, strong competition for raw materials from domestic (Thai, Indonesian) starch processors, and the continuing pressure for the reduction of cassava production lands, further influenced by cassava supply and price cycles.

Major Dutch pellet traders foresee a 1998 pellet import volume of 1.4-1.6 mmt into Rotterdam, or approximately 110,000 t/month (personal communications, ATRACO Ltd and IAT, Rotterdam). However, up to 5 years ago, Holland imported double this volume. Furthermore, while Germany used to import an average 1.0 mmt/year, pellet imports this year have nearly been suspended (personal communications, Alfred Toepfer International, Hamburg). The principal cause is the reduced margin between cassava pellet and its EU substitutes. Imports were high when this margin was dfl 60/t or more. In April 1998, the Rotterdam cif pellet price including tax was around dfl 215/tons compared to EU maize of dfl 230/ton, hence a margin of only dfl 15/ton. If these pellets are shipped further to Germany at a rate of DM 7-8/t, the price advantage of cassava pellet is largely eroded.

Besides significant problems of maintaining a price edge, concerns over deteriorating pellet quality have increased. While EU import regulations specify a minimum pellet starch level of 60 percent, up to the mid-90's, this was not a problem since average pellet starch contents were as high as 70 percent. More recently, Thai cassava pellet imports have been detected with starch contents of 55-57 percent. These fluctuations not only cost money to feed millers, they also cause serious problems in maintaining consistent nutrition levels in the feed formulas. Some feed millers nowadays will pay as much as US$ 10/T premium, for pellets with a 70 percent (10%+) starch content. The reduction of cassava pellet starch contents seems to be an indication of the increased inclusion of cassava starch processing by-products (bagasse) in the pellets (Personal communications, ATRACO, Rotterdam).

The historical European import trend during the last 5 years has been downward regarding Thai cassava pellets. Given that EU feed grain intervention prices may be further reduced, or in the best-case scenario, remain at a constant level; it seems most probable that pellet imports will continue to slide in the future. A variable that may somewhat change this bleak picture, is the price of soymeal and the devaluation of the Thai baht. Given large predicted 1998 harvests in the main soybean producing countries, decreasing soymeal prices may somewhat widen the margin between cassava-soy mixtures and EU maize or barley. The devaluation of the Thai baht has also tended to make cassava more competitive.

Future European demand for imported cassava pellets and chips is highly dependant on developments of the growth of pig numbers in the EU and the price of substitutes (feed-grains and other grain substitutes) and complements (animal and vegetable proteins). Strict environmental laws have already limited the potential for further increased pig production, especially in North European countries (the principal and traditional consumers of imported cassava).

The bottom line is that the only real window of opportunity for cassava pellets to regain some of their lost European market is a significant pellet price reduction. This directly implies the need for reducing per unit, cassava root production costs in Thailand.

From the demand side, it has already been argued that the European derived demand for imported cassava depends on the pig industry growth (or lack of) and relative prices of feed grain substitutes and complements. From the supply side, the major constraint is cassava pellet prices, or rather Thai cassava root prices.

The birth of cassava pellet and chip imports from SE-Asia, during the 60’s, was principally related to EU policy conditions (loopholes in CAP import regulations) and the subsequent cassava boom was largely managed by various EU policy measurements. Subsequently the current downturn of the pellet imports has also been policy-induced. In the future, EU grain intervention prices will continue to be under pressure, further reducing the margins for imported cassava. In the cassava growing countries a significant shift towards starch manufacturing has occurred, putting further pressure on the pellet industry (competing for the same raw material). The future for cassava pellet imports, again, depends to a large extent on future EU policy developments and the further capacity of the Thai pellet industry to reduce costs. This has to come from higher cassava productivity, stabilisation of prices and improved industry organization.

The following sections include discussions of the cassava chip and pellet export activities of Ghana and Thailand.

Case Study: Ghana

Andrew Graffham and Andrew Westby

The European Union feed market for dried cassava is well established. The EU has allocated a quota of 145,000 tonnes to World Trade Organisation members, excluding Thailand, Indonesia and China. This quota has never been reached. But it is noted by traders that the pig-feeding industry in Bretagne could absorb as much as 10,000 MT/month of chips from West Africa. The chips would of course have to be at appropriate price, quality and supplied throughout the year (Personal communications, IAT, Rotterdam).

In Ghana three local companies (Transport & Commodity General (T&CG), GAFCO and SILTEK Exports) sought to exploit the opportunity offered by the WTO quota. However, by 1998 only T&CG was still involved in this business. GAFCO and SILTEK Exports had withdrawn from the market for reasons that will become apparent later. This case study focuses on the activities of T&CG.

T&CG entered the cassava chip market in 1993 in partnership with Tranex, a livestock feed brokerage based in Belgium, that supplies feed ingredients to a number of feed millers in Belgium and France. Initial exports were of negligible size but in 1996 the company exported 19,725 tonnes to the EU. During this period the company purchased cassava chips for US$30/tonne[23] (farm gate price) and sold cassava for anything up to US$152/tonne. In 1997, however, the average dried cassava price fell to $100/tonne (FAO Food Outlook, November 1997). In the first quarter of 1998 T&CG's input and output prices for dried cassava chips were US$40 and US$70/tonne respectively.

In the early stages of operations T&CG attempted to establish a centralized processing operation but this proved expensive and inefficient. An improvement on this approach involved creating mobile processing teams to tour the production areas chipping and drying cassava on site. Ultimately the company settled on farm-level processing as the most effective option. Initially the company provided manually operated chipping machines, but as these proved expensive and unreliable, the company switched to a policy of encouraging farmers to chip by hand using a knife. Individual farmers harvest and wash roots before chipping and then sun dry at the field edge. Some farmers were equipped with concrete drying floors but as this proved

[23] Prices throughout this report have been converted from local currencies to U.S. dollars at the applicable exchange rate at the time the data refers to. Prices have not been adjusted for inflation

expensive, T&CG have been encouraging farmers to use traditional wooden drying screens made from lengths of bamboo. Under normal conditions chips are reported to take about 2 days to dry.

A general specification for cassava chips intended for export to the European Community for use in livestock feeds is given in Table VII-3. Chips should be white or near white in colour, free from extraneous matter, moulds, insect infestation and damage and possess no peculiar odours. In addition, shipments of chips must not contain significant amounts of dust, as this is considered unacceptable by European importers.

Table VII-3: Specification of cassava chips for livestock feed

Parameter	Percentage
Moisture (maximum)	10-14%
Starch (minimum)	70-82%
Total Ash (maximum)	1.8-3.0%
Crude Fibre (maximum)	2.1-5.0%
Sand and other extraneous matter (maximum)	3%
Cyanide (maximum)	100mg /kg
Dimensions (maximum in cm)	Length 4-5cm, thickness 1.5cm.

This market opportunity has been mainly influenced by changes in Ghanaian policy and economic factors. But it would be true to say that improvements in the network of major roads linking inland areas of Ghana with the coastal cities and major ports would have made Brong Ahafo a more attractive production area for this purpose.

A number of Districts in Eastern, Volta, Ashanti and Brong-Ahafo Regions produce more than 100,000 tonnes of cassava per annum (Day et al. 1996). However, not all Districts are appropriate as sources of cassava for export as many have good access to fresh markets or competing processed products that command higher prices than cassava chips. In practice T&CG has concentrated on six Districts in Brong Ahafo Region where large amounts of cassava are grown, drying conditions are good but farmers' access to alternative markets is poor. Production is decentralised with 4-5 production zones per district. Each zone contains a number of farmers organized into groups to supply chips to T&CG, farmers groups are expected to supply a minimum of 25 tonnes of marketable chips per month. Farmers are expected to deliver chips to one of 20 zonal buying agencies that then forward batches of chips to the zonal buying centre, for onward transport by road or lake to the company's warehouses in the port of Tema. When sufficient chips have accumulated, chips are forwarded by ship to the companies feed broker (Tranex) in Europe who take responsibility for distribution of chips to the feed millers.

The major physical bottlenecks associated with T&CG's activities are:

Transport infrastructure. The main production zones have a low level of road infrastructure and lack linkages from field areas to the main roads. In addition there is almost no mechanization of transport from field to road. Dry chips have to be head loaded through the bush to reach the road. This is an activity that increases labour costs and reduces flow of supplies to the collection points.

Equipment. In an attempt to increase production rates, the company introduced a manual-chipping machine. This machine proved costly, inefficient and unreliable under field conditions. Motorized equipment was not considered an option due to unacceptable high capital costs (*ibid*).

Labour shortages. This is an ongoing problem in rural Ghana. Manual chipping requires a high labour input that is not always readily available.

Farmer confidence. Farmers involved in this venture valued the benefits of regular income and guaranteed market access. The success of the company in 1996 led farmers to have high expectations of market returns and sustainability. However, the collapse of world prices for dry cassava in 1997 (FAO 1997) led to cash flow problems, many farmers lost confidence with the company and switched to other markets for their product.

Expansion difficulties. To create a large supply of chips within two years, T&CG operated a policy of rapid expansion into nine Districts in Brong Ahafo and Northern Regions. In each District the company had to provide extension support to raise awareness among farmers, provide training and establish field-based management systems that could provide the necessary level of quality control. In retrospect, the company recognises that this level of expansion was too rapid, and was partly responsible for failings in quality control.

Quality. The policy of decentralised production can lead to problems with establishing and maintaining consistent quality standards. Farmers can be tempted to increase production at the expense of quality. The most common problems are mould spoilage, contamination with sand, and high moisture contents due to inadequate drying. The dimensions of chips may also fail to meet the importers specification.

Supply problems. Increases in the price of fresh roots and dry cassava chips for local human consumption have made it difficult for T&CG to source enough chips to meet their contractual obligations.

Handling methods and loading rates. Low levels of mechanization at the company's facilities in Tema have resulted in very low loading rates, typically 500 - 1000 tonnes per day. In contrast a similar company in Thailand would expect to load 20,000 tonnes per day. The problem of bulk handling is a key constraint as it increases shipping costs.

Power supply. Since January 1998 Ghana has been experiencing a national power shortage resulting from a combination of several years of unusually dry weather, increased demand for both water and electricity and problems with the operation of the nations main source of power generation. This is a serious problem that may take several years to resolve.

The initial success of T&CG's operation was influenced by several factors, these are:

Competitiveness of cassava as a feed ingredient. In the period from 1993 to 1996 dry cassava, with a suitable protein supplement, was able to compete in Europe on a price basis with alternative feed ingredients such as barley and maize.

Access to funds to develop the opportunity. It is difficult to put a figure on the cost of developing a market opportunity but T&CG have estimated that a minimum of US$600,000 were required for research and development over a 5 year period in order to exploit this opportunity. The European backer Tranex supplied a substantial amount of this money.

Farmers' interest in chip production. In the production zones identified by T&CG, farmers faced problems with access to markets for fresh cassava roots and relatively poor prices for dry cassava for local human consumption (kokonte). Although the equivalent fresh root price was three times higher than that offered by T&CG for dry chips (Day *et al.* 1996), farmers valued the opportunity offered by T&CG. The opportunity promised ease of market access, a regular and guaranteed income stream, payment by weight (which farmers considered to be fairer than volume basis), prompt payments and the possibility of credit from the company.

Positive policy environment. During the early stages of the development of this opportunity, a positive policy environment for cassava development existed in Ghana. Cassava was identified as a first priority crop in the National Research Strategic Plan (NARSP) and Medium Term Agricultural Development Plan (MTADS). The MTADS recognised the importance of adding value to cassava through income generating opportunities, expanded markets and interventions by the private sector.

Although demand for dry cassava remained steady throughout 1996 and 1997, changes in market prices during 1997 placed a severe stain on T&CG. In 1997 world cassava prices fell from US$150 to US$100/tonne. In the same period reductions in set-aside subsidies within the EU depressed the price for barley. In addition the price of soy-meal (protein supplement required for cassava feeds) was very high. It is clear that under these conditions cassava can only maintain its competitiveness by becoming cheaper. Unfortunately this is not a viable option for T&CG, which faces very high production and transport costs when, compared to major competitors in South East Asia. The problems of the European market affected the company's cash flow and interfered with payments to farmers in the production zones.

In Ghana unusually dry conditions attributed to the *El Nino* weather system lead to increases in prices for both kokonte and fresh cassava for local consumption. Many farmers who were already upset by the uncertainty of payment by T&CG switched to alternative outlets. In three Districts in the Northern Region, kokonte prices increased to US$0.13/kg. T&CG, who could only offer US$0.04/kg, was unable to compete and had to withdraw from these areas.

In addition to these problems, the company is limited by the very high costs associated with transport and handling of the product in Ghana, and difficulties in sourcing lines of credit to maintain cash flow through a difficult period.

The case of T&CG provides an example of a complete commodity system where all the stakeholders have a vital role to play in ensuring the successful exploitation of the opportunity. Farmers are the primary stakeholders in this system and they have the responsibility for providing a constant supply of chips of consistent quality. If the farmers lose confidence in the market or fail to pay attention to quality, the system will collapse. T&CG has a key role in providing the farmers with a point of access to the market and technical and financial supports to exploit the opportunity, as well as providing a management structure to co-ordinate supplies and maintain quality control. The presence of a large and organized purchasing organization should also help to build the confidence of the farmers as to the sustainability of the opportunity. If the buying organization fails, then farmers will not be able to access international market. The European feed broker provides a means of reaching the feed millers in Europe, and this case has also provided a substantial financial commitment. Without the feed broker it seems unlikely that T&CG could have developed the opportunity or accessed the European markets so readily.

As noted above, there is little reason to assume that the EU market for animal feed is going to increase. Of course there is the possibility that the market share of some exporters can increase at the expense of other exporters. There is also the possibility of short-term increases in the market. For example, EU traders are currently taking out future contracts on dried cassava shipments, in the belief that large harvests of soybean predicted for the U.S. and Brazil will reduce soy-meal prices during 1998 and thus improve the competitiveness of cassava (personal communication Alfred Toepfer Gmbh, Hamburg). However this must be set against current trends in the prices for barley and maize. During 1998, EU barley prices have remained low and large harvests of maize in Argentina and the U.S. could make maize a strong contender against cassava in the short term.

To continue to exploit this business opportunity against competition from alternative feed ingredients and markets in Ghana, T&CG needs a high level of capital investment. This would reduce the costs associated with transport and handling of the product and thus reduce the sale price of the product to a more competitive level. In addition financial backing is required to maintain cash flow and farmer confidence during times of reduced world market prices for dry cassava.

The case of T&CG provides a good example of a commercial company attempting to address the problems of a complete commodity system using a mixture of commercial and developmental techniques. This case provides many useful pointers for the development of any cassava processing option in the future.

T&CG concentrated solely on the export market, as this seemed to offer the largest market and maximum opportunity for a good return on initial investment. In retrospect it is clear that the company would have been wise to consider domestic markets for high quality cassava chips as well, because this would have provided a buffer against fluctuations in the world market price for dry cassava. Within Ghana potential opportunities exist for dry chips in the domestic livestock markets and for the manufacture of industrial adhesives and glue extenders.

Marketing dry cassava internationally appears attractive as a means of adding value, expanding market opportunities and providing a source of foreign exchange. This information coupled with knowledge of the examples provided by Thailand, Indonesia and China could attract many nations growing cassava to try and enter the market. However, prospective entrants need to be aware of the unpredictable nature of the EU cassava market, and must prepare themselves for mixed trading fortunes and stiff competition from South East Asia. To have any chance of success prospective entrants should take the following factors into consideration:

Do they have access to a reliable supply of good quality cassava at low prices in country all year round (seasonal problems can be overcome to some extent by stock piling)?

Do they have access to a modern seaport with bulk handling facilities?

How good is the transport infrastructure linking the production areas with the seaport?

What will be the estimated cost of dry cassava from production to final delivery in Europe and how does this compare with the lowest prices recorded in the EU market?

Can they provide an effective management structure in the production areas to provide training and support to farmers, maintain quality and ensure consistency of supplies?

Do they have access to sufficient capital to develop the opportunity and reserves to maintain cash flow during periods of market depression?

What measures could be taken to maximize efficiency and minimise production costs?

Do the farmers have access to alternative national markets, and will these markets divert supplies away from the export market?

Case Study: Thailand

Boonjit Titapiwatanakun

The experience of Thailand, as a leading exporter of cassava products, is instructive to potential exporters in what can be done and what must be done to be successful. The objective of this section is to provide an overview of the Thai cassava industry and to identify the key factors that have contributed to the Thai success. This section provides detail about the supply chain from cassava production to export and serves as a benchmark for other would-be exporters. As indicated in Figure VII-1, although 10 other countries export more than 10,000 tonnes of cassava chip (root equivalence), Thailand and Indonesia are the dominant exporters of cassava chip worldwide.

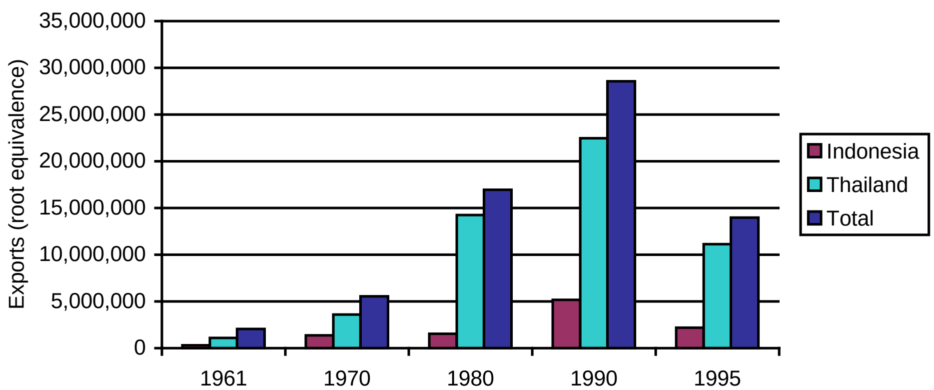

Figure VII-1: Cassava Chip/Pellet Exports by Indonesia, Thailand and Global (root equivalence)

1.1. Development of the Industry

The development of the cassava industry in Thailand can be divided into 3 phases, each dominated by a partially processed cassava product.

1940's to 1966, Starch: It is believe that cassava was introduced into the Southern region of Thailand from Indonesia. Until the 1940's, cassava was grown in the eastern seaboard of Thailand. During the World War II, cassava root was processed into starch, using a simple technology, and used to satisfy the domestic demand since Thailand was unable to import starch from abroad. Shortly after World War II, modern technologies were imported for processing cassava starch for both domestic consumption and export. This led to the gradual development of the eastern seaboard of Thailand as a cassava starch industrial region directed towards export.

1967 to 1993, Animal feed: In 1962, waste or pulp residuals from cassava starch processing were dried and exported to European countries as a cereal substitute ingredient in animal feed. The highly protected cereal market caused by the EEC's Common Agricultural Policy (CAP) created a market for cereal substitutes in the EEC and triggered the development of cassava products for animal feed in Thailand. Hammer mills were imported from Germany for producing cassava, or tapioca meal, for export. Concurrently, cassava chips were produced to replace both starch waste and hammer milled cassava exports, which were facing quality problems. Cassava chips however were bulky and freight costs were high. Consequently, cassava pellets, processed from chips by pelleting, were produced using imported pelleting machines from Germany. It did not take long before the local mechanical engineers were able to produce a cheaper pelleting machine than the imported pelleting machines. The local machines produced a relatively softer quality cassava pellets or native pellets than the imported one. This enabled a rapid expansion in the native pellet industry, all of which was destine for the EEC market.

The quantity of cassava product exported as animal feed increased from 506.2 thousand tons of chips and 97.1 thousand tons of pellets in 1967 to 487.2 thousand tons of chips and 6,694.4 thousand tons of pellets in 1982. The increase in planted area and production of cassava was spectacular. At the beginning of the export era, 1967, about 177 thousand rais (6.25 rais = 1 hectare) of cassava was planted with a production of 337 thousand tons. By 1978 cassava area increased to 7.3 million rais with a production of 16.4 million tons of roots. By 1989 the area devoted to cassava grew to 10.1 million rais and a production of 24.3 million tons.

After 1989, a decreasing trend of both planted area and production has been observed. Area and production have declined to 7.9 million rais and 17.4 million tons in 1996, respectively (Table VII-4). Given the fluctuations in national average yields of 1,969 to 2,281 kg/rai (12.3 to 14.3 tones/ha) the increase in root production has been via area expansion rather than yield improvement[24].

[24] It is important to note that Thai yields of cassava have been relatively stable in a system that is probably the most intensive in the world. This observation suggests that cassava production is more sustainable than it is sometimes credited to be.

Table VII-4: Planted areas, production, production costs, farm gate price and returns (1978-1996)

	Production			Cost and return		
	Planted area	Production	Yield	Total cost	Farm gate price	Return
	1,000 rai)	(1,000 tons)	(kg/rai)	(baht/kg)	(baht)	(baht/kg)
1978	7,281	16,358	2,246.67	0.28	0.78	0.50
1979	5,286	11,101	2,100.08	0.34	0.74	0.40
1980	7,250	16,540	2,281.38	0.41	0.53	0.12
1981	7,940	17,744	2,234.76	0.43	0.61	0.18
1982	8,418	18,764	2,229.03	0.45	0.53	0.08
1983	8,552	18,989	2,220.42	0.44	0.62	0.18
1984	8,780	19,985	2,276.20	0.46	0.67	0.21
1985	9,230	19,263	2,087.00	0.43	0.38	-0.05
1986	7,748	15,255	1,968.90	0.44	0.74	0.30
1987	8,820	19,554	2,217.01	0.41	0.91	0.50
1988	9,879	22,307	2,258.02	0.41	0.61	0.20
1989	10,136	24,264	2,393.84	0.39	0.55	0.16
1990	9,562	20,701	2,164.92	0.45	0.67	0.22
1991	9,323	19,705	2,113.59	0.49	0.76	0.27
1992	9,323	20,356	2,183.42	0.56	0.76	0.20
1993	9,100	20,203	2,220.11	0.59	0.67	0.08
1994	8,817	19,091	2,165.25	0.60	0.59	-0.01
1995	8,093	16,217	2,003.83	0.63	1.15	0.52
1996	7,885	17,388	2,205.20	0.68	0.98	0.30

The expansion of the EEC cereal substitute market and the sharp increase of Thai cassava into the EEC attracted the attention of EEC's cereal producing countries and the EEC Commission. Eventually, Thailand signed a Voluntary Export Restraint Agreement (VER) or officially called " The Cooperation Agreement between the Kingdom of Thailand and the European Economic Community of Manioc Production, Marketing and Trade" in 1983 for a period of 4 years. Under the agreement Thailand agreed to limit the export of cassava to the EEC. In return, the EEC gave Thailand 75 million ECU to assist in the diversification of its production. Since then three such agreements have been signed, the last in 1994.

After the implementation of the VER in 1983, the Thai government has closely monitored cassava products for the animal feed industry, with active intervention through different measures, especially in the allocation of export quota to the EEC. At least two significant changes have taken place during this period. One, economies of scale in processing and marketing have been gained by the expansion of warehouse facilities and the adaptation of modern mechanical loading and unloading facilities. Two, dust pollution problems at the port of entry in Europe were solved by the introduction of hard pellets in 1989.

1994 onward, Starch and modified starch: The first sign, to the cassava industry, that the artificial cereal substitute markets, for cassava products in the EEC, had reached its peak was the signing the VER. This fact was reinforced by the implementation of CAP reform in 1994. Understanding these signals, Thai processors and traders of cassava began to diversify or integrate into cassava starch processing. They also began producing modified starches through joint ventures with established developed country firms in the U.S., Japan, and Europe (the Netherlands, Belgium, UK and Finland).

Throughout these phases, cassava has been a profitable crop for the Thai farmer. Between 1978 and 1996, the computed farmers' returns were negative in only 2 years of the 18 years, 1985 (-0.05 baht/kg) and 1994 (-0.01 baht/kg). As illustrated in Table VIII-2 total production costs of root on average have increased from 0.28 baht/kg in 1978 to 0.68 baht/kg in 1996[25], while farm gate prices have fluctuated in the range of 0.38 to 1.15 baht/kg.

1.2. Marketing and Distribution

An examination of the marketing channel and price formation of cassava and cassava products is simplified by examining the product flows and price determination of farm price (root price) and the final product (chip, pellet, native starch and modified starch) prices.

In Thailand, cassava roots are sold either at the farm gate or to middlemen. There are two distinct markets for cassava: the animal feed market using chips and pellets, and the native and modified starch markets. Processed cassava products are sold for export and domestic consumption. For example, cassava chips may be sold to pellet factories, exported or used in the domestic market as animal feed. The price for each cassava product is the free market price at each market level (Figure VII-2).

Figure VII-3 illustrates the competitiveness and efficiency of the cassava industry's pricing system. The price movement of root, chip, pellets and starch are very similar over time. From 1982-1997, the annual average price of fresh root at the factory fluctuated from 630.67 baht/ton to 1,618.00. The average price was 945.29 baht/ton or approximately $43/tonne. An upward trend is observed during 1982-1995. In 1982 the prices of chips and pellets were 2,030.00 baht/ton and 2,399.20 baht/ton, respectively, in 1995 prices were 3,011.00 baht/ton and 3,157.80 baht/ton, respectively. Similarly, the domestic wholesale price of cassava starch grade A increased from 4,427.08 baht/ton in 1982 to 8,404.00 baht/ton in 1995. Since 1995 prices have been falling. Grade A starch has decreased to 5,987.00 baht/ton in 1997[26] as well as the domestic wholesale price of chips and hard pellets and fresh root price.

---

[25] The farm gate price of cassava roots were approximately $U.S. 19 and $U.S. 45 per tonne, respectively for the two time periods.

[26] The average exchange rates for 1982, 1995 and 1997 were 23.05, 25.60 and 25.39.

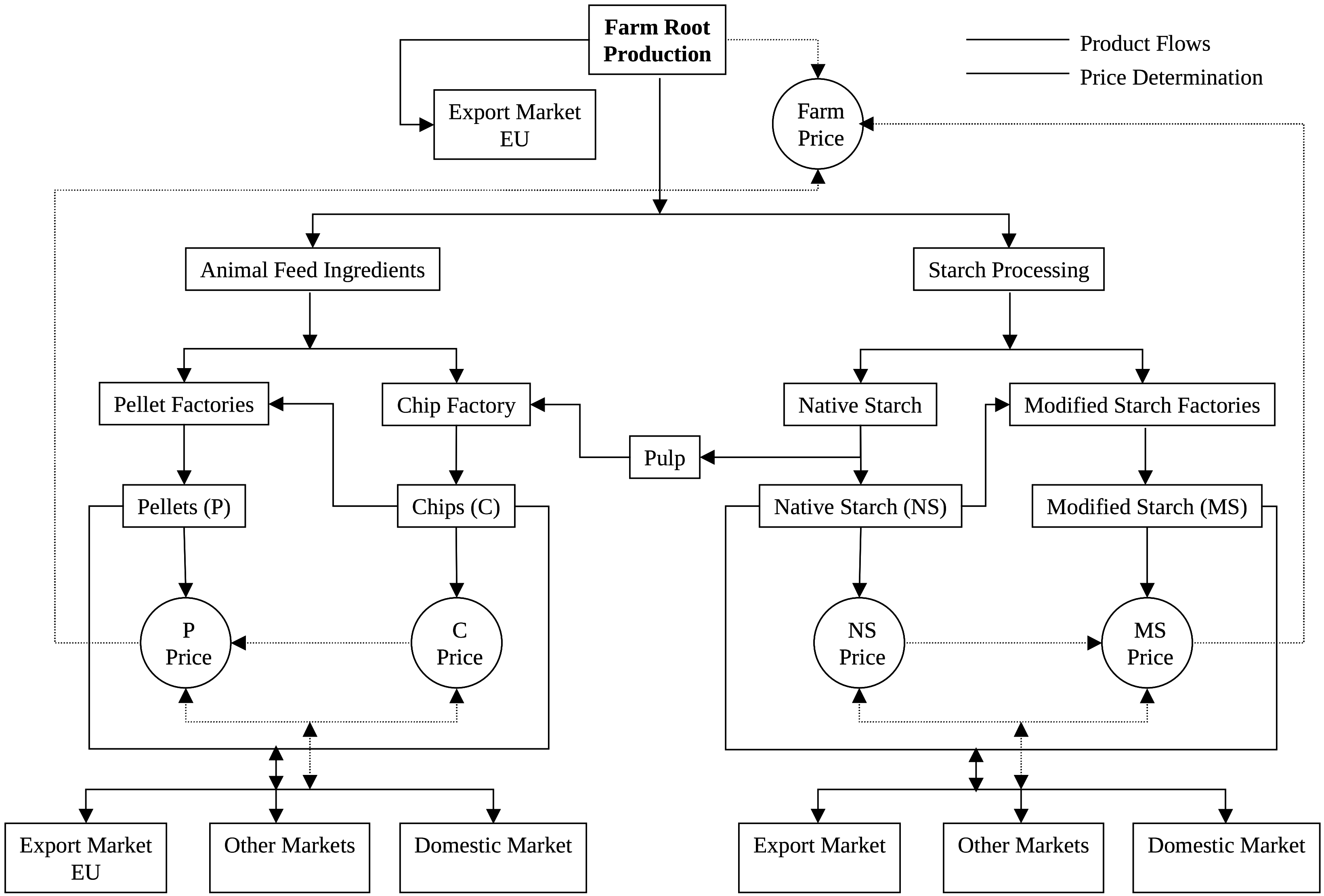

Figure VII-2: Simplified marketing flow and price determination of cassava industry in Thailand,

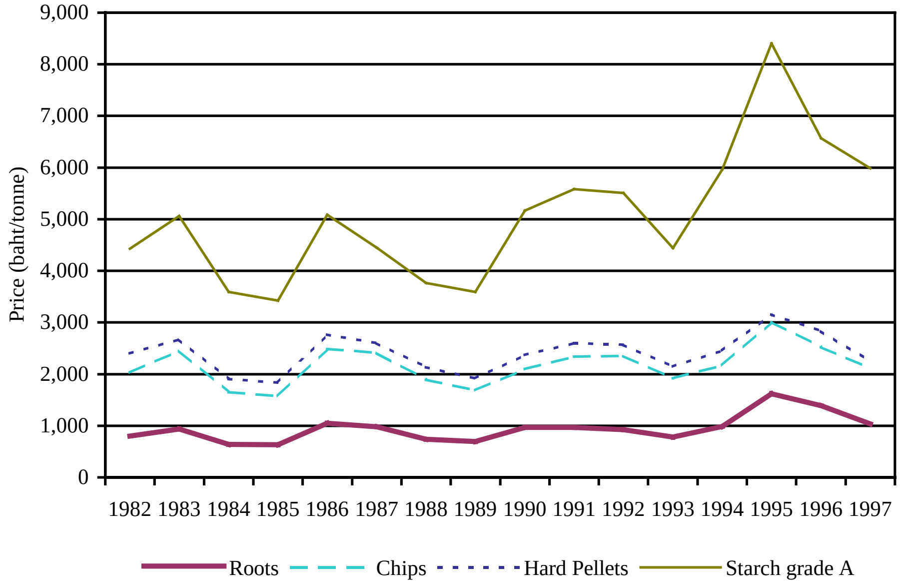

Figure VII-3: Domestic prices of cassava roots, hard pellets and starch grade A

Cassava product processing costs are influenced by the size of the factory and the number of operating days per year. The current financial crisis has also had a strong impact on processing costs. Traders estimate that in 1997/98 the processing costs of cassava chip were 100 baht/ton, 250 baht/ton for pellet and 1,800 baht/ton for native starch. It is worth noting that these processing costs were estimated for established factories. One would expect that the processing costs for newly established factories would have been much higher.

Transportation costs are an important component of the pricing system. Of benefit of late, are the improvement in the efficiency of export handling and procedures. For example, the current export cost is 300 baht/ton, substantially less than costs in 1992 of 500 baht/ton. The current average domestic cost to transport cassava product from the major cassava-producing province (Nakhon Ratchasima) to Bangkok is about 250 baht/ton.

Another important development that has lowered transportation costs has been the development of basic infrastructure in Thailand. Statistics obtained from the Ministry of Finance show that the total government budget for transportation and communication programmes increased from 554 million US$ in 1983 to 3,548 million US$ in 1997. This is an annual compound growth of 18 percent. The budget allocated to land transportation is the highest at 93%, followed by air transportation and water transportation at 3.2% and 2.9%, respectively. (Table VII-5).

Table VII-5: Government budget for transport and communication programs in selected years (million US$)

	Admin	Transportation				Total
		Land	Water	Air	Telecom	
1983	1.02	512.07	18.37	11.20	1.34	544.00
1987	1.52	448.76	20.42	12.27	1.91	484.88
1992	4.67	1,132.90	31.62	69.44	3.12	1,241.75
1997	8.38	3,285.89	85.38	190.20	14.90	3,548.75
Growth rate	17.65	18.06	9.72	20.54	18.29	17.88
Avg. % Share	0.46	93.00	2.96	3.20	0.38	100.00

Source: Ministry of Finance

1.3. Growth Opportunities

The Thai cassava industry was developed within a free market price system with little or no government intervention. The industry participants and private firms (both Thai and subsidiaries of trans-national companies) have successfully developed a market-driven demand into a massive cash crop production. They have also successfully solved most of the trade-related problems through negotiation among the trading parties. The one area where the government did intervene in the trade negotiations was in dealing with trade protectionism policies implemented by importing countries.

Since 1982, the export animal feed trade has been closely regulated, with sporadic interventions in the price of roots by concerned government agencies. Intervention in cassava starch processing and trading has occurred only periodically. In general the cassava starch industry has enjoyed a relatively government free market environment.

Although the decision by the government to impose regulations on cassava trade, in the form of export quotas to the EU, was not appreciated by cassava industry stakeholders, after many reformulations a workable quota allocation method was put in place. Based on the computed average farmers' return, the so-called workable solution has benefited farmers since its establishment in 1982 until 1997. Moreover, the export earnings of cassava products have ranked among the top five commodities in Thailand, making cassava a top strategy crop of Thai agriculture.

Prior to 1970, Thailand was not a major cassava producing country. In two decades (1970s-1980s), Thailand became a major cassava producing country and a leading exporter. The key factors that contributed to that growth and development are identified below:

Food: rice is the major staple, of which Thailand is a major exporter; therefore, cassava is not a staple food in the Thai diet.

Land: degraded forest lands were opened up for cash crop production; the land was suitable for cassava grown under rain fed conditions allowing massive area expansion of cassava root.

Climate: a distinct raining and dry season made sun drying a low cost possibility, especially for cassava chips.

Infrastructure: the government has constantly improved and expanded the road transportation infrastructure, setting the conditions for a viable low cost transport system which has reduced the handling costs of processed cassava products.

Free market environment: Thailand has maintained a free enterprise policy and has encouraged private sector investment. The government has well-established rules and regulations that guarantee private sector property rights.

Technological transfer through joint ventures: Thai private firms and trans-national firms have realised the mutual benefit of joint ventures in using low cost comparative advantage to capture export markets and penetrate existing markets.

Processing and handling: Investments in both processing and handling occurred as soon as the industry grew to a viable size. Investors adopted new technologies and gained benefits of economies of scale.

Active entrepreneurs in agricultural sector: An adequate number of entrepreneurs in Thai agriculture allow for a very competitive industry.

Well-organized and co-operative associations: A number of associations exist for producers, processors and traders. These associations are, to a large extent, well established and organized and co-operate among themselves.

Dialogue between public and private sector: Well-established associations enable dialogue between public and private sectors to solve problems faced by the industry and identifying common interests in research and development. Domestic public and private sectors are also connected to international institutions.

As noted already, the catalysts for the development of the Thai cassava export industry was the creation of the European Economic Community and its resulting Common Agricultural Policy (CAP). The CAP opened the market to the importation of cereal substitutes. Although the Europeans promoted the export of cassava from several countries, only Thailand, and to a lesser extent Indonesia, responded to the opportunity. The Thai response was nothing less than spectacular as indicated in the following table.

As noted in the preceding section, numerous natural and man-made factors contributed to the development of the Thai cassava industry. The most impressive fact is how rapidly it grew in the 'sixties and 'seventies. By 1968, Thailand had reached a level of cassava export that only Indonesia had previously been able to achieve. To put Thai export volumes into perspective, Thailand exports 14,000 mt of processed product on average **daily**. This is equivalent to a daily fresh root export of approximately 40,000 mts.

Table VII-6: Some key data on Thai cassava export industry

Year	Area (1,000 ha)	Production (1,000 mt)	Exports (1,000 mt)	Number of Drying Plants	Number Processin g Plants	Export Price of Pellets (US$/mt)
1963			483			
1968			875	90	28	$50.00
1978	1,164	16,350	6,275			
1988	1,580	22,307	8,107			
1989	1,621	24,264	9,799			
1996	1,262	17,388	4,500			$123.00
1997	1,008	16,875	5,062		~44	$82.00

The export oriented cassava chip and pellet industry is currently facing serious changes. For the past three decades, Thai cassava chips and pellets have been an export-oriented industry. Since the early 1980s and the signing of VER agreements between Thailand and the EEC, the industry has tried to develop alternative export markets. Although these efforts have intensified since CAP reform in 1994 new markets have not materialized. Total exports continue to decline, from 6.7 million tons, of which 5.2 million tons was exported to the EU, in 1993 to 4.2 million tons, of which 3.2 million tons was exported to the EU, in 1997. It is hoped that total exports will stabilize soon at about 3 million tons per year.

An alternative marketing plan that is being actively explored is the utilisation of chips and pellets as animal feed, domestically (see Chapter IV). Other opportunities for new and expanding exports exist in the starch market, particularly that of modified starch. This market depends, however, on high technology levels that can meet constantly changing product demands. Here too, domestic demand for modified starch is a growing market opportunity (see Chapter III).

Conclusions

The European market for cassava chips and the resulting benefits for exporters, especially those from Thailand and Indonesia, have spurred an interest in cassava as an export crop. This excitement has to be tempered, however, by the fact that this market came to life because of a loophole in the European agricultural policy. The rapid growth of the market peaked in 1989 and has been in a state of decline ever since. Attempts to restrict Thai exports to Europe began first in the early eighties and were the substance of a 1983 agreement between the EU and Thailand to restrict Thai exports of chips and pellets to Europe.

In principle, the restrictions placed on Thailand's exports, opened the door for other countries to fill the void, but none did. The Ghana case study illustrates one unsuccessful attempt to fill the void.

The Thai success in exporting cassava illustrates what is needed to develop export markets for cassava. The Thai case is also illustrative of many of the factors that are outline in the Global Strategy for Cassava (Plucknett, Phillips, and Kagbo 1998). One, the EU, owing to the creation of the Common Agricultural Policy, created a growth opportunity based on *competition.* Two, European importers of animal feed ingredients were both *catalysts* and *champions* for the industry in many cassava producing countries. Indonesia and Thailand, however, were the only countries able to seize the opportunity. Three, Thailand was fortunate to have good *supporting infrastructure* - roads, ports and an entrepreneurial class of agricultural exporters. Four, Thai farmers, who were unfamiliar with the production of cassava, quickly appreciated the commercial benefits to growing cassava, and *rapidly expanded the production* of the crop. Five, another group of entrepreneurs quickly realised the benefits of drying cassava, and establishing *numerous drying "plants"* in cassava growing areas. Six, the market, especially the processors, *adapted to changing market conditions and requirements* - producing first chips, then pellets and finally hard pellets. Seven, everyone in the supply chain appeared to understand the need to be *competitive* and price gouging was not obvious. Finally, industry and government *re-invested* in the industry as demonstrated by the activities of the Thai Development Research Institute.

While the development of the Thai cassava chip and pellet export industry was not planned, the requisite conditions were in place, or created, to promote the industry. The Thai industry is instructive of what would be needed to develop new markets for cassava whether it is for domestic or export use.

Summary and Conclusions

Truman P. Phillips and Daphne S. Taylor

The objective of this study *was to identify viable business opportunities for the use of cassava.* The report has explored the domestic and export opportunities for the three major markets for cassava, food, starch and animal feed. The global examination of these markets was based on the analysis of 64 countries that produced at least 10,000 metric tonnes of cassava in 1995. Case studies of individual country activities in these different markets were used to identify factors that contribute to the development of these market opportunities. The case studies, in keeping with the *Global Strategy for Cassava,* identified some of the key stakeholders who helped to develop and support the market opportunities.

The analysis indicates that business opportunities exist for the use of cassava, but not necessarily for all cassava-producing countries. In very general terms domestic markets appear to offer greater opportunities than export markets. Domestic food market opportunities in particular. The case studies consistently pointed out that the development of any market opportunity depends on a reliable supply of competitively priced cassava of the appropriate quality.

The market opportunities will be discussed in the order they were presented.

Domestic Market Summary

Food: The analysis of the 64 studied countries suggests that a market opportunity exists for the use of cassava as a food. It was noted in the Brazilian case studies that the development of new market opportunities must respect existing markets. That is developing one market at the expense of another market does not indicate a net gain in the market for cassava. If however, the growth of the market respects existing markets and creates an additional demand for cassava then there is a net benefit to cassava producers and others in the supply chain. Market opportunities were measured in terms of the additional demand that might occur by the year 2005 relative to what it was in 1995.

1995 was taken as the base period because it was the last year that complete data for the 64 studied countries was available. The additional production required to meet new market requirements was used as a proxy of additional demand. It was assumed throughout this study that additional demand would in turn have positive impacts on the development process. This assumption was confirmed by the case studies that illustrated that there are a number of stakeholders who benefit from the creation of additional markets for cassava. These benefits can extend to having national consequences as illustrated by the use of cassava flour in Nigeria. This case study suggested that the use of cassava flour could save Nigeria US$14.8 million/year in foreign exchange.

The market for cassava as a food appears to provide the greatest potential for the greatest number of countries. The available national data permitted two market opportunities to be evaluated - namely the urban market for cassava and the wheat and wheat flour import substitution market. It was argued that urbanisation effectively increases the number of domestic consumers who will potentially purchase and consume cassava.

The import substitution market refers to the opportunity of using domestically produced cassava flour as a partial replacement for imported wheat and wheat flour. This market is attractive because of its foreign exchange saving features and because the demand for products based on wheat and wheat flour is growing. The results of the examination of these two market opportunities suggest that by the year 2005 forty-eight of the sixty-four studied countries could see an additional demand of greater than 10 percent of 1995 production (Table 1).

Table 1: Summary of major food market expansion opportunities by 2005

Africa		Asia		Latin America	
percent increase over 1995 cassava production due to Urbanization					
Mozambique	46%	Philippines	25%	Dominican Rp	22%
Congo, Rep	36%	Malaysia	21%	Venezuela	22%
Guinea	29%	Cambodia	16%	Ecuador	18%
Angola	24%	Laos	14%	El Salvador	18%
Kenya	23%	Indonesia	14%	Guatemala	18%
Cote d'Ivoire	22%			Nicaragua	17%
Cameroon	21%			Fr Guiana	17%
Tanzania	21%			Colombia	17%
Comoros	20%			Peru	16%
Zimbabwe	19%			Bolivia	14%
Madagascar	17%			Panama	12%
Nigeria	16%				
Senegal	16%				
Sierra Leone	14%				
Congo, Dem R	14%				
Togo	14%				
Zambia	13%				
Benin	12%				
Ghana	12%				
Guinea bissau	12%				
Niger	12%				
Cent Afr Rep	12%				
Gabon	11%				
percent increase over 1995 cassava production due to Wheat Substitution					
Senegal	118%	China	104%	Guatemala	422%
Somalia	35%	Sri Lanka	102%	Jamaica	227%
Zimbabwe	17%	Malaysia	73%	El Salvador	146%
		Myanmar	32%	Ecuador	120%
		Philippines	31%	Venezuela	100%
				Panama	96%

Table 1: Summary of major food market expansion opportunities by 2005

Africa	Asia	Latin America	
		Cuba	95%
		Peru	59%
		Dominican Rp	55%
		Nicaragua	50%
		Guyana	48%
		Costa Rica	38%
		Bolivia	34%
		Haiti	17%
		Colombia	16%
		Fr Guiana	12%

The general results are that the growing urban market may be the most promising avenue for development of a cassava industry in a majority of the studied African countries. In Latin America, the most promising development opportunity for a number of the studied countries might be replacing 10 percent of imported wheat. The reference price for cassava roots, as determined by average import costs, is between US$36.00 and US$75.00/ tonne. This reference price includes transportation and processing costs.

Obvious development of either of these two domestic food market opportunities will require market development and the delivery of the appropriate quality and price of product to the consumer, be they individuals in the cities or bakeries. The potential market caused by urbanization may also mean that traditional products need to be modified, such as making them more convenient to use, and packaged in a manner that is consistent with urban living. Also cassava flour will only be used if it affectively meets the quality standards of imported wheat flour. As noted in the Nigerian case study if *wheat is readily available at a low cost it remains the favoured raw material for bakery products.* The reality of the situation is that wheat is not readily available at a low cost. Changes in the value of national currencies and international trading regulations have increased the relative price of wheat and wheat flour (see Ghanaian and Nigerian case studies on the use of cassava flour).

The Brazilian case study of pão de queijo illustrates how a common cassava-based food can grow into a rather large industry. The growing popularity of pão de queijo and the creation of coffee shop chains that feature pão de queijo has created a lucrative fast-food. As an indication of the impact of this market on the members of the supply chain - one of the markets Forno de Minas, which makes frozen pão de queijo now has annual sales of US$40 million - ten times what they were in 1994. This case study also illustrated that as the market grows there needs to be changes in the product to reflect the increasing needs for a high quality, easily handled and standard product.

Starch: The potential for the domestic starch market for the 64 countries studied above could not be analysed, owing to data limitations. Available data did show that most of the studied countries imported some form of starch with glucose and dextrose being the most common imports. All of these starches can be replaced in part by cassava starches. The amount of import substitution that is possible depends on the use of the starch. While country level analysis was not possible, the case studies showed that there are both emerging and existing country opportunities for the domestic use of cassava starches.

The case study of Benin, Ghana and Malawi illustrated that the small size of the market is a barrier to the development of the market. In Benin, for example only 120 tons of starch is reportedly used. While it is technically feasible to replace some of this starch with cassava starch (some of the import starch is in fact cassava starch) it is very difficult to domestically establish a plant to produce cassava starch. It was suggested in the case study that to be viable a "traditional" starch plant would minimally work a 100 days of the year with a daily output of at least 4 tonnes of starch per day - or 400 tonnes per year. This is substantially larger that the current needs of Benin.

The annual starch demands for Malawi (780 tonnes) and Ghana (4,200 tonnes) would justify domestically producing cassava starch. The case studies illustrated that there are in fact domestic cassava starch factories, but that these factories still face problems of quality of the final product. Nevertheless the feasibility of using cassava starch has been demonstrated, as has the competitiveness of cassava starch.

The Brazilian case study examined cassava starch as an established industry producing 300 thousand tonnes per year. The production of modified starch has grown during the past five years and now constitutes 30 percent of cassava starch. The market is continuing to grow. The Brazilian cassava starch supply chain differs from almost all other countries in the world by having an increasing number of farmers that grow more than 1,000 hectares. This is in contrast to Thailand in which most of the cassava farmers have holdings of 1 to 5.7 hectares.

The Thai case study demonstrated that while the Thai cassava starch industry is export orientated, its domestic consumption is several times larger than Brazil's consumption of cassava starch. In fact, in 1997 Thailand produced 512 thousand tonnes of modified starch and syrups for the domestic market. About an equal amount of native starch was consumed domestically. The Thai case study highlighted the role played by the export sector in promoting the domestic use of cassava. Thailand has a well-funded development institute (the Thai Tapioca Development Institute Fund) that is investing in the domestic market for cassava. It is probably fair to claim that no other country in the world is doing as much to promote cassava markets. Interestingly enough it is the traders and processors that are leading the way.

Chips: Domestic use of cassava as an animal feed is probably the least developed of the domestic markets. One indication of the potential is given by the increasing trend in maize imports into a number of the studied countries. Assuming that much of this maize is going to animal feed, the figures suggest that there is a growing feed compounding industry. As has been shown by the Europeans, cassava can replace maize and other grains given the right prices of cassava and protein rich ingredients. Thus in cassava producing countries it is technically possible to replace some of the imported maize by cassava. Assuming that 10 percent of imports could be replaced produced the following table.

Table 2: Summary of major animal feed market expansion opportunities by 2005

Africa		Asia		Latin America	
percent increase over 1995 cassava production due to Maize Substitution					
Malawi	31%	Malaysia	135%	Guatemala	273%
Rwanda	22%	China	84%	Jamaica	256%
Senegal	12%			El Salvador	148%
				Panama	131%
				Dominican Rp	123%
				Venezuela	88%
				Costa Rica	69%
				Peru	48%
				Cuba	24%
				Colombia	16%
				Nicaragua	16%

Clearly Latin American countries appear to have the greatest potential for market growth for cassava by using it as a substitute for maize. The target import substitution price for roots, processing and transportation included, ranges from US$57 to US$63/tonne. This is similar to the target price for wheat and wheat flour import substitution. But in many cases it could be assumed that the processing cost of producing cassava chips for animal feed would be lower than those of producing cassava flour.

The Brazilian case study of cassava chips in the state of Ceará confirmed that there is a market potential for cassava as a domestic animal feed ingredient. The Thai case also illustrates that there is a domestic market for cassava as an animal feed ingredient. But the Thai case study demonstrates the importance of being competitively priced. Even in Thailand, as the analysis shows, there have been times that cassava-soybean mix or cassava-fishmeal mixes were not competitive with domestic maize.

The Zimbabwe case study illustrates some the factors that need to be considered to try and develop a fledgling animal feed industry that uses cassava. The problems or opportunities facing Zimbabwe are that they do not traditionally grow cassava; they have a small intensive animal feed industry and a small food compounding industry. Clearly these problems must be faced when trying to develop the cassava animal feed market, but these same issues, if overcome, suggest that it could be possible to develop the industry.

All the case studies identified factors that could act as bottlenecks to the development of domestic market opportunities. At the risk of over simplification, Table 3 was created to highlight the bottlenecks identified in the different case studies. The most commonly identified bottleneck was the lack of a reliable supply of cassava. In Zimbabwe, where they are, at times, introducing the cultivation of cassava there was even a lack of good planting material. Lack of equipment, mechanization and power were also mentioned on several occasions as bottlenecks to developing the industry.

Some less frequently mentioned bottlenecks, but perhaps as important as those above, are infrastructure, consumer acceptance, education/training of key actors in the industry, and good weather for drying cassava. Almost all cassava-based products require drying. The large volume of water in cassava leads to the observation that the only economical way of drying cassava is sun drying. Unfortunately in many cassava-producing countries this is only possible during part of the year. A related issue about drying cassava is that the cassava processing by-products do not have much value. The overall value of cassava is enhanced if new and improved ways of dealing with waste can be found.

Infrastructure, say in the form of roads, extension services and credit facilities, was identified as being a positive contributing factor to the development of cassava markets in Thailand and Nigeria, and bottlenecks in some of the other case studies.

The domestic market potential in the year 2005 indicated in Tables 1 and 2 is equal to 36 million tonnes of roots or 22 percent of 1995 production. Without a doubt the growth potential of the domestic markets is substantial and can contribute to national development.

Export Market Summary

The export market has been the source of much interest in trying to develop cassava markets that in turn are hoped to spur the economics of cassava producers. As noted in Part 2 of this report the export markets have in fact had periods of impressive growth. One reason this grow has been impressive is that it has occurred with little national and international support. No doubt many have concluded that even greater advances could be made for cassava markets if more were done, say by national and international organizations, to promote and develop cassava markets. As summarized above there appear to be a number of domestic market opportunities that in part require support on the part of national governments to realize the potential.

In the three export market areas there have been impressive successes. One, in food markets, the Costa Rican export of paraffin-coated cassava to Europe and North America. Two, in the starch market, modified starches have been the most dynamic. And three, the European market for cassava, as an animal feed ingredient, has been a great success.

The chapters in Part 2 of this report shed some light on the factors that have contributed to the growth of these markets, and the likelihood that these markets will continue as growth areas.

Food: The largest market of cassava as an exported food has been for paraffin-coated cassava. The major importers are North America with imports of nearly thirty eight thousand tonnes and Europe with imports of five thousand tonnes. The prime exporter is Costa Rica. This market exists because of the discovery of the paraffin coating process, or less frequently used CO_2 filled plastic bag process, that extends the shelf life of fresh cassava roots. The market is driven by ethnic communities in European, normally of African dissent, and North America, normally Hispanics.

The case studies pointed out that the paraffin-coated cassava is more appropriate for the North American market than the European market. In Europe cassava pastes or flour would be more consistent with traditional consumption patterns.

The positive growth factors for this market are that these ethnic communities are growing in both Europe and North America. In North America, supermarkets are catering to the ethnic markets and are marketing traditional foods like cassava. If the present consumption levels are maintained, the growth in the Hispanic population in North America would suggest that the demand for paraffin-coated cassava could increase by 40 percent by 2005. In both Europe and North America there are indications that "non-ethnic" communities are becoming more interested in "exotic" foods such as cassava. Unfortunately, most of the "non-ethnic" market does not know what cassava is, or how to prepare it. If the market is to expand, the product needs to be promoted.

The negative growth factors for cassava as a exported food are that second and later generations of ethnic communities may be less likely to consume cassava, as they adopt the eating patterns of the non-ethnic communities. A second deterrent to the growth of the fresh market is it's price. The European case study points out that the price is relatively high when compared to other carbohydrates. In North America fresh cassava is sold as a loss-leader. Thus the retail price, at least from the point of view of the supermarkets, may be too low. Unless there is an increased demand for paraffin-coated cassava it is unlikely that supermarkets will continue to sell it. The future for this market depends on continued consumption of cassava by the ethnic market, with increased consumption by the non-ethnic market.

The case studies indicated that there were other food markets for cassava such as frozen cassava, cassava French-fries and cassava flour. Unfortunately not much information is known about these markets. The cassava flour import market is small, but a niche market could develop if bakery, confectionary and pasta products using cassava flour were manufactured and marketed for individuals with Celiac Disease. Currently in North America the major manufacturers reportedly do not think that the market is large enough to justify development. The import market for frozen and cassava French-fries is relatively new in Europe and North America. It would seem that these markets could grow, but they will probably only grow if the large food processors decide to promote the products. The intension of these large food processors is unknown at this time.

Starch: Cassava starch trade coverts a diversity of products that are not normally delineated by available data - and are not in the FAO data set used for much of the analyses. Nevertheless, it is known that there are many more importers of cassava starch than there are exporters. As was shown in Chapter VI, Thailand is the dominant exporter accounting for approximately 85 percent of world cassava starch exports. In 1990 China and Japan accounted for about 80 percent of global starch imports. In 1995 China, Indonesia, Malaysia and Japan accounted for 81 percent of global starch imports.

The case studies of European and North American starch markets demonstrated the fact that a nation's preferred starch is based on the most abundant supply of raw material available. In North America the preferred starch in maize starch, while in Europe a variety of starches are preferred depending in part on the geographical region. The preferred starches are potato, wheat and maize. The relatively large imports by China and Japan partially reflect the fact that these countries do not have an abundant raw material source for starch manufacturing.

The strongest markets for cassava starch in Europe and North America appear to be in the adhesives and food and beverage industries. In times of high maize and maize starch prices the North American paper industry becomes a large importer of cassava starch. Cassava starch does not inherently have properties that make it a preferred starch for the paper industry other than price when cassava starch is relatively cheaper.

The case studies relating to starch in Brazil, Europe, North America and Thailand indicate a growth potential for modified cassava starch. For the producing countries much of the commercial development of modified starch production has been in conjunction with European and North American starch producers. The resulting product is normally produced for the European and North American starch producers. There is little indication that cassava-producing countries have produced modified starches exclusively for domestic purposes.

Chips: The import-export market for cassava chips and pellets is the European-Thai story with support from Indonesia. As pointed out in Chapter VI Thai and Indonesian exports account for ninety-five percent of European imports of cassava chips and pellets. Thai exports of chips and then pellets increased yearly from nothing in the early sixties to 6 million tonnes in 1978. Exports then oscillated around the 6 million tonne level until 1988. From 1988 to 1992 exports oscillated around 8 million tonnes. Since that time there has been a steady decline of Thai cassava chips and pellets exports. The decline in Thai exports has not been as great as the decline of the European import of cassava chips and pellets. Thailand has successfully found alternative importers of cassava chips and pellets, however the demand from these countries has not been reliable. The main alternative markets have been China and South Korea.

The European case study highlighted how initial agricultural policies of the European Community created the market for cassava, and how changing

European and World policies regarding agricultural trade and protection are eroding the market for cassava. Many suggest that the European demand for cassava pellets is going to further decrease. This report has taken a more optimistic view that the European market may remain fairly stable. The rational is that the Thai financial crises and resulting devaluation has made cassava more competitively priced. Secondly, Thailand has a lot of sunk cost in the capacity to produce cassava pellets therefore the Thais may be able to export cassava pellets for as long as the export price covers variable costs.

The implication is that the Thais, and presumably the Indonesians will continue to supply the European pellet market for as long as it exists. And there will be little opportunity for other countries to enter the market except to supply the WTO members quota of 145 thousand tonnes. As the Ghana cassava chips export case study reported it is very difficult for new entrants to survive in this limited market.

In summary there appear to be new, but not clearly defined, market opportunities in the cassava food and starch export markets. To get an independent assessment the Thai Tapioca Trade Association (TTTA) was asked for their opinion about the future for cassava. Mr. Teera, TTTA Manager, graciously agreed to consulted TTTA member on their view of the future. The following is an attempt to summarise their responses. The assistance of the TTTA is gratefully acknowledged, but they are not responsible for any errors of interpretation that may have been made.

Q1: In your opinion what are your expectations for the future (next 10 years) for tapioca products?

	Export	*Domestic*
Chips	Decrease	Increase
Pellets	Decrease	Constant
Native	Constant	Increase
Modified Starch	Increase	Increase

Q2: In your opinion what are the most likely growth areas for tapioca products? (for example: paper manufacturing; animal feed ingredient; human food uses, etc.)

	Export	*Domestic*
Chips	Alcohol	Animal Feed
Pellets	Animal Feed	Animal Feed
Native	Industry & Food	Industry & Food
Modified Starch	Industry & Food	Industry & Food

Q3: Where will the export growth markets be located? (countries)

	Export
Chips	China, South Korea
Pellets	S.E. Asia
Native	China, USA, EU
Modified Starch	China, USA, EU

Q4: What do think might limit the development of these potential market opportunities?

	Export	*Domestic*
Chips	Import Quota/Tax	Marketing, High Price
Pellets	Quota/Tax, Marketing	Quality, High Price
Native	Quota/Tax, Marketing	Marketing, Price
Modified Starch	Quota/Tax, Marketing	Marketing, Price

From the Thai perspective the major export growth opportunity is the modified starch market to China, the U.S.A. and Europe. The Thais see quotas, taxes and marketing problems to be the greatest barriers to growth for this opportunity. The Thais appear to be optimistic about domestic opportunities for cassava chips and starches. The Thais did not discuss the cassava food market because Thailand has very little experience in this market.

The review of cassava exports illustrated that it is difficult to predict before hand what are going to be the successful markets, or if any country is going to become the dominant exporters. Nevertheless when a country seizes the opportunity, as Thailand and Costa Rica have, it can be seen that the rewards are great. Clearly a large number of small farmers, traders, small and large processors, and ancillary industry members have benefited for the three plus decades of cassava exports from Thailand. While not easy, it would seem that other countries could also experience success in some new market opportunity.

Conclusions

This study attempted to *identify viable business opportunities for the use of cassava.* It was found that 54 of the 64 studied countries have the potential to develop new domestic market opportunities that could require, by the year 2005, market growth of more than 10 percent of the 1995 production level. These markets, if established, are linked into the national economics. These markets should continue to grow as the economy grows as well as contribute to the growth of the economy. The potential contribution of these cassava-based markets is highlighted by the Nigerian estimate that a 15 percent replacement of imported wheat flour with cassava flour could result in an annual foreign exchange saving of US$ 14.8 million. Only three cassava-producing countries (Thailand, Indonesia and Costa Rica) had foreign exchange earnings greater than the import substitution available to Nigeria. The development of domestic markets is largely in the hands of the country. If a viable opportunity exists and the key stakeholders are willing to work towards and contribute to the development of the market it should happen.

Export market opportunities appear to be less robust than domestic market opportunities. All export markets can be characterized as being driven by final demand. The ethnic communities in Europe and North America are driving the cassava food market. The producers of final products like paper, textiles, adhesives, food and beverages in Europe and North America are driving the starch market. These industries continually search for the cheapest starch that has the specific properties required by the industry. If the starch does not exist, the industry will try and create the starch. Finally, the animal feed industry and the EU Common Agricultural Policy are driving the cassava chip and pellet imports.

The exporters do not drive these markets. Even the dominant exporters - Thailand in the cassava pellet and starch markets, and Costa Rica in the paraffin-coated cassava food market - can do very little to alter market developments. The advantage of Thailand and Costa Rica is that they are constantly looking for new markets for their existing products. If they find a new demand for their products they generally are in a position to seize these opportunities.

It would appear that when it comes to developing new international market opportunities cassava producing countries have to be considered *market takers* not *market makers*[27]. It would appear that any country that wants to enter into international markets should have a soundly based national market for cassava. As was concluded in the Ghana cassava chip export case

> *T&CG concentrated solely on the export market, as this seemed to offer the largest market and maximum opportunity for a good return on initial investment. In retrospect it is clear that the company would have been wise to consider domestic markets for high quality cassava chips as well, because this would have provided a buffer against fluctuations in the world market price for dry cassava. Within Ghana potential opportunities exist for dry chips in the domestic livestock markets and for the manufacture of industrial adhesives and glue extenders.*

[27] We are adapting the economic term of price takers and price setters. Price takers cannot influence the selling price of the goods price setters can. Rational price takers only enter markets with acceptable prices.

Table 3: Summary of factors identified as potential bottlenecks to development of cassava markets

Cassava Chips - for animal feed			Cassava Flour - for wheat flour substitution			-for Industrial purposes	Cassava Starch	- for Pão de queijo	- for Biscoito de polvilho	Frozen cassava fries
Ghana Exports	Zimbabwe Domestic	NE Brazil Domestic	Ghana	Nigeria	Ghana		Brazil			
Transportation Infrastructure	Biennial cropping system	Lack of working capital	Consistent supply of high quality chips	Access to processing equipment	Lack of technical information	Cassava supply and seasonality	Low level of mechanisation of cultivation	Low and unstable quality of cheese	Very localised	Consistent supply of raw material
Chipping equipment	Encroachment by wild and domestic animals	Land tenure	Power for processing	Power to provide mechanisation		Root maturity	Market concentration of corn starch	Low and unstable quality of sour starch	Little or no market development	High investment costs
Labour shortage	Access to drought power	Inconsistent demand	Consumer acceptance	Good weather for drying		Water and power supplies	Low educational level – poor technical sales	Small size of sour starch factories	Limited quality control	
Farmer confidence	Access to sufficient planting material	Low yields					Lack of information			
Expansion difficulties	Yields						Price fluctuations			
Quality	Transportation									
Supply problems	Extension system									
Handling methods and loading rates										
Power supply										

Appendices

Appendix VI-1 Uses of Starch

International Starch Institute
Science Park Aarhus, Denmark

APPLICATIONS of STARCH, STARCH SYRUP and BY PRODUCTS

http://home3.inet.tele.dk/starch/isi/applic/applic.htm

Snacks
High amylose cornstarch is also used in extruded and fried snack products to obtain crisp, evenly browned product and hampers penetration of cooking oils. High amylose cornstarch requires higher cooking temperatures, typically 150-170 ^{o}C, to gelatinise properly.
Tapioca starch exhibits good clarity and bland flavour. It has good film-forming characteristics with resistance to cracking and chipping. It may be used at a concentration of twenty per cent. The film-forming properties of ***Tapioca*** dextrin's make it effective as a replacement for gum Arabic in the pan coating of confections. This dextrin can be used as a non-tacky glaze for cakes, donuts, fruit, nuts and candies.
Baking
High maltose and high conversion syrups improve moisture retension and colour control in final product. Dextrose syrup improve crust and doug properties. High fructose syrups are used in frosting and fillings.
Baby food
Maltodextrin and starch is used as a nutrient with low fermentability. Dextrose as an energy source
Noodles
Adding potato starch or better a dual esterifed starch with low gelatinisation point and a high peak viscosity to noodles improves their consistency and mouthfeel. The starch will gelatinise and absorb water before the wheat flour takes over and dominate the viscosity profile.
Sauces
A pizza sauce gets improved eye appeal and mouthfeel from a cold water swelling pregelatinized starch. A cross-linked instant starch is easy to disperse in cold mixtures or oil and adds a pulpy and richer look to fruit based sauces. Cross-linking imparts the starch with resistance in acid foods and will even allow retorting.

Meat products
Modified waxy maize, potato or ***tapioca*** starch added at the chopping stage swells during heating and binds in poultry rolls and meat loaves as well as other cooked meats. The final texture will be firm and retained for prolonged periods. Starch may reduce drip during smoking of meats and weeping of vacuum packed foods. Starch is also used as a skim milk in replacer.
Low calorie foods
HFSS 90 is used in low calorie food applications, due to its high sweetening power to calorie ratio.
Tapioca based modified starch can be used as a fat mimetic in dairy systems due to its bland flavour. A low-fat product can be prepared with the organoleptic and textural properties of a traditional fat containing product.
Soft drinks
High fructose starch-based syrup (HFSS), although originally introduced in 1967, it was the fructose level increase to 55% in 1978 which resulted in sugar's loss of the soft drink market. HFSS can be produced at considerably lower costs than sugar, giving this product a competitive advantage over sugar. High fructose starch-based syrups (HFSS) are used for soft drinks as a sugar replacement with similar sweetness. HFSS 55, is a most concentrated sweetener used primarily in beverages. It is a direct replacement of sugar. HFSS 42, an all-purpose sweetener, does also find uses in beverages. HFSS stabilize the flavour profile.
Beer
High maltose syrups find use as wort syrup in beer production. It is an excellent fermentation substrate and fermentation can be controlled by the sugar spectrum of the syrup. Some yeast species are sensitive to high concentrations of glucose but maltose does not have any suppression effect on yeast.
Alcohol
Very high DE glucose syrups are used as a fermentation booster in alcohol fermentation. Dextrose syrup has the advantage, that it is completely used up and do not add to by-products and may improve throughput when capacity is exhausted.
Marmalade and jam
For proper texture, jellied fruit products require the correct combination of fruit, pectin, acid, and sugar. Sugar serves as a preserving agent, contributes flavor, and aids in gelling. Cane and beet sugar are the usual sources of sugar for jelly or jam. Starch syrup may be used to replace part of the sugar in recipes, but too much will mask the fruit flavor and alter the gel structure. Too little sugar prevents gelling and may allow yeasts and molds to grow.

Medium high glucose syrup - 63 DE - replaces sugar in marmalade and jam. To provide good shelf life a high sugar concentration is required and for the purpose a 63 DE syrup is preferred to the traditional 42 De syrup. High conversion syrups and HFS adds more sweetness and increase osmotic pressure (better shelf life).
Canning
Maltodextrins and low conversions syrups add body to canned sauces. High conversion syrups add body and sweetness to canned fruit. HFS add seetness.
Foundries.
Starch is used as a core binder in castings (cast molds).
Animal feed
Starch is used as a binder and nutrient in animal feed pellets. wet as is like roughage or dried. The dried pulp finds some use as a moisture absorber in soft foods for fur animals and fish. Wheat gluten is used as a meat extender or replacer in pet food Potato protein is a valuable protein for for animals and small pigs.
Concrete
Starch finds use as a retarder in concrete. Starch products are used for reducing set-time in cement.
Oil drilling
Pregelatinized starch is used to increase viscosity of drilling mud and to reduce fluid loss by sealing the walls of boreholes . Cross-linking imparts higher temperature stability. Starch ethers impart tolerance to polyvalent cations and sea water. Starch are usedand for increasing the viscosity of transport and cooling water.
Gypsum & Mineral Fiber
Starch is used as a binder in gypsum plaster, gypsum and mineral fibre board
Nappy / Diaper
Starch is used as an adhesive.
Diapers with superabsorbent gelling materials in their core has been developed with gelling materials capable of sequestering 80 times their weight of moisture. Starch based products may substitute high-molecular-weight, cross-linked sodium polyacrylate polymers as the absorbent.
Water

Starch products are used as flocculants in many industrial water treatment plants for flocculation purposes.

Coal

Briquettes made of coal dust and fines are bound with starch as a binder

Detergent

Starch finds use as a redeposition inhibitor of dirt once it has been released from the fabric.

Pharmacy

Starch acts as a binder in pharmaceutical tablets and as a disintegrating agent as well.

Special starch is used as dusting powder and surgical glove powder.

Ice cream

Starch products are used as crystal and texture controller. High maltose and high conversion syrups control softness and freezing characteristics. Recipee.

Today's ice cream has the following composition:

· greater than 10% milkfat - usually between 10% and as high as 16% fat in some premium ice creams
· 9 to 12% milk solids-not-fat: this component contains the proteins (caseins and whey proteins) and carbohydrates (lactose) found in milk
· 12 to 16% sweeteners: usually a combination of sucrose and glucose syrup
· 0.2 to 0.5% stabilizers and emulsifiers
· 55% to 64% water which comes from the milk or other ingredients

A sweet ice cream is usually desired by the consumer. As a result, sweetening agents are added to ice cream mix at a rate of usually 12 - 16% by weight. Sweeteners improve the texture and palatability of the ice cream, enhance flavors, and are usually the cheapest source of total solids. In addition, the sugars contribute to a depressed freezing point so that the ice cream has some unfrozen water associated with it at very low temperatures typical of their serving temperatures, -15° to -18° C. Without this unfrozen water, the ice cream would be too hard to scoop.

It has become common in the industry to substitute all or a portion of the sucrose content with sweeteners derived from starch syrup. This sweetener is reported to contribute a firmer and more chewy body to the ice cream, is an economical source of solids, and improves the shelf life of the finished product. Starch syrup in either its liquid or dry form is available in varying dextrose equivalents (DE). As the DE is increased by hydrolysis of the starch, the sweetness of the solids is increased and the average molecular weight is decreased. This results in an increase in the freezing point depression, in such foods as ice cream, by the sweetener. The lower DE starch syrup contains more dextrins which tie up more water in the mix thus supplying greater stabilizing effect against coarse texture.

HFSS High fructose starch-based syrup can be used to a much greater extent in sucrose replacement. However, these HFSS further reduce the freezing point producing a very soft ice cream at usual conditions of storage and dipping in the home. A balance is involved between sweetness, total solids, and freezing point.

Confectionery

High conversion glucose syrups replase sucrose and imparts products with less hygroscopicity and a better viscosity profile. High maltose syrups controls moisture and texture in soft confections.

Candy

High amylose cornstarch contains as much as 70% amylose compared to 25-28% in ordinary cornstarch. This makes it a particular strong gelling agent in the manufacture of fine jelly gum candies. High amylose cornstarch is used in combination with normal fluidity starches (thin boiling starches). Up to half the starch is commonly replaced by high amylose starch to obtain quick setting candy piece with an attractive texture.

Tapioca speciality dextrin's replaces from 20% to 40% of gum Arabic in some hard gum candies.

Agriculture

Copolymerizing starch with acrylonitril and alkaline hydrolysis gives a super absorbing polymer, "Super-Slurper" used for coating of seeds to improve presence of water for faster germination and to improve water capacity of soil for potted plants.

Stain remover

To remove a stain with an absorbent powder, sprinkle a layer of starch powder over the stain. Spread the starch round, and as soon as it becomes gummy lift, shake or brush it off. Repeat this until nothing further is being absorbed. If a mark still remains after this, mix the powder to a paste, using water for non-greasy stains and a grease solvent (see "for greasy marks"). Leave standing till dry, then brush off.

Dusting powders

Dusting powder consists of finely powdered substances free of grittiness. They are used on normal intact skin prophylactically to reduce friction (talc) or moisture (starch). By cross-linking starch can be stand sterilising in autoclave and be used as surgical dusting powder.

Paper

Thin-boiling starches is used as sizing on most paper. Cationic starches are used as wet-end additives improving filler retension and reducing effluent load. Starch is used for for coating.

Corrugated board

Native starch in mixture with pregelatinized starch is applied on top of the corrugated flute before lining. The native starch acts as an instant glue with good tack when heat is applied.

Card board may be produced by gluing liners together with a starch based glue.

Textile
Starch is used for sizing yarn to improve abrasion resistance in fast looms. Starch is is used for finishing fabrics to add feel, stiffness or to provide a good printing surface. Thin-boiling starches are preferred.
Plastics & Packaging In plastics starches improve the biodegradability of plastic and finished products.

Appendix VI- 2 US Starch Regulations

110[Code of Federal Regulations]
[Title 21, Volume 3, Parts 170 to 199]
[Revised as of April 1, 1998]
From the U.S. Government Printing Office via GPO Access
[CITE: 21CFR172.892]

[Page 108-109]

TITLE 21--FOOD AND DRUGS

CHAPTER I--FOOD AND DRUG ADMINISTRATION, DEPARTMENT OF HEALTH AND HUMAN SERVICES (CONTINUED)

PART 172--FOOD ADDITIVES PERMITTED FOR DIRECT ADDITION TO FOOD FOR HUMAN CONSUMPTION--Table of Contents

Subpart I--Multipurpose Additives

Sec. 172.892 Food starch-modified.

Food starch-modified as described in this section may be safely used in food. The quantity of any substance employed to effect such modification shall not exceed the amount reasonably required to accomplish the intended physical or technical effect, nor exceed any limitation prescribed. To insure safe use of the food starch-modified, the label of the food additive container shall bear the name of the additive ``food starch-modified'' in addition to other information required by the Act. Food starch may be modified by treatment prescribed as follows:

(a) Food starch may be acid-modified by treatment with hydrochloric acid or sulfuric acid or both.

(b) Food starch may be bleached by treatment with one or more of the following:

	Limitations
Active oxygen obtained from hydrogen peroxide and/or peracetic acid, not to exceed 0.45 percent of active oxygen.	....
Ammonium persulfate, not to exceed 0.075 percent and sulfur dioxide, not to exceed 0.05 percent.	....
Chlorine, as calcium hypochlorite, not to exceed 0.036 percent of dry starch.	The finished food starch-modified is limited to use only as a component of batter for

	Limitations
	commercially processed foods.
Chlorine, as sodium hypochlorite, not to exceed 0.0082 pound of chlorine per pound of dry starch.	....
Potassium permanganate, not to exceed 0.2 percent.	Residual manganese (calculated as Mn), not to exceed 50 parts per million in food starch-modified.
Sodium chlorite, not to exceed 0.5 percent	....

(c) Food starch may be oxidized by treatment with chlorine, as sodium hypochlorite, not to exceed 0.055 pound of chlorine per pound of dry starch.

(d) Food starch may be esterified by treatment with one of the following:

	Limitations
Acetic anhydride.........................	Acetyl groups in food starch-modified not to exceed 2.5 percent.
Adipic anhydride, not to exceed 0.12 percent, and acetic anhydride.	Do.
Monosodium orthophosphate................	Residual phosphate in food starch-modified not to exceed 0.4 percent calculated as phosphorus.
1-Octenyl succinic anhydride, not to exceed 3 percent.	....
1-Octenyl succinic anhydride, not to exceed 2 percent, and aluminum sulfate, not to exceed 2 percent.	....
1-Octenyl succinic anhydride, not to exceed 3 percent, followed by treatment with a beta-amylase enzyme that is either an approved food additive of is generally recognized as safe..	Limited to use as a stabilizer or emulsifier in beverages and beverage bases as defined in Sec. 170.3(n)(3) of this chapter.
Phosphorus oxychloride, not to exceed 0.1 percent.	....

	Limitations
Phosphorus oxychloride, not to exceed 0.1 percent, followed by either acetic anhydride, not to exceed 8 percent, or vinyl acetate, not to exceed 7.5 percent.	Acetyl groups in food starch-modified not to exceed 2.5 percent.
Sodium trimetaphosphate..................	Residual phosphate in food starch-modified not to exceed 0.04 percent, calculated as phosphorus.
Sodium tripolyphosphate and sodium trimetaphosphate.	Residual phosphate in food starch-modified not to exceed 0.4 percent calculated as phosphorus.
Succinic anhydride, not to exceed 4 percent.	....
Vinyl acetate............................	Acetyl groups in food starch-modified not to exceed 2.5 percent.

(f) Food starch may be esterified and etherified by treatment with one of the following:

Acrolein, not to exceed 0.6 percent and vinyl acetate, not to exceed 7.5 percent.	Acetyl groups in food starch-modified not to exceed 2.5 percent.
Epichlorohydrin, not to exceed 0.3 percent, and acetic anhydride.	Acetyl groups in food starch-modified not to exceed 2.5 percent.
Epichlorohydrin, not to exceed 0.3 percent, and succinic anhydride, not to exceed 4 percent.	....
Phosphorus oxychloride, not to exceed 0.1 percent, and propylene oxide, not to exceed 10 percent.	Residual propylene chlorohydrin not more than 5 parts per million in food starch-modified.

-- ----------------------------

(g) Food starch may be modified by treatment with one of the following:

-- ----------------------------

Limitations

-- ----------------------------

	Limitations
Chlorine, as sodium hypochlorite, not to exceed 0.055 pound of chlorine per pound of dry starch; 0.45 percent of active oxygen obtained from hydrogen peroxide; and propylene oxide, not to exceed 25 percent.	Residual propylene chlorohydrin not more than 5 parts per million in food starch-modified.
Sodium hydroxide, not to exceed 1 percent.	....

(h) Food starch may be modified by a combination of the treatments prescribed by paragraphs (a), (b), and/or (i) of this section and any one of the treatments prescribed by paragraph (c), (d), (e), (f), or (g) of this section, subject to any limitations prescribed by the paragraphs named.

(i) Food starch may be modified by treatment with the following enzyme:

Enzyme	Limitations
Alpha-amylase (E.C. 3.2.1.1).............	The enzyme must be generally recognized as safe or approved as a food additive for this purpose. The resulting nonsweet nutritive saccharide polymer has a dextrose equivalent of less than 20.

[42 FR 14491, Mar. 15, 1977, as amended at 43 FR 11697, Mar. 21, 1978; 46 FR 32015, June 19, 1981; 57 FR 54700, No v. 20, 1992; 58 FR 21100, Apr. 19, 1993]

[Code of Federal Regulations]
[Title 21, Volume 3, Parts 170 to 199]
[Revised as of April 1, 1998]
From the U.S. Government Printing Office via GPO Access
[CITE: 21CFR178.3520]

[Page 375-376]

TITLE 21--FOOD AND DRUGS

CHAPTER I--FOOD AND DRUG ADMINISTRATION, DEPARTMENT OF HEALTH AND HUMAN SERVICES (CONTINUED)

PART 178--INDIRECT FOOD ADDITIVES: ADJUVANTS, PRODUCTION AIDS, AND SANITIZERS--Table of Contents

Subpart D--Certain Adjuvants and Production Aids

Sec. 178.3520 Industrial starch-modified.

Industrial starch-modified may be safely used as a component of articles intended for use in producing, manufacturing, packing, processing, preparing, treating, packaging, transporting, or holding food, subject to the provisions of this section.

[[Page 376]]

(a) Industrial starch-modified is identified as follows:

(1) A food starch-modified or starch or any combination thereof that has been modified by treatment with one of the reactants hereinafter specified, in an amount reasonably required to achieve the desired functional effect but in no event in excess of any limitation prescribed, with or without subsequent treatment as authorized in Sec. 172.892 of this chapter.

List of reactants	Limitations
--	------------------------------
Ammonium persulfate, not to exceed 0.3 pct. or in alkaline starch not to exceed 0.6 pct..	
(4-Chlorobutene-2) trimethylammonium chloride, not to exceed 5 pct.	Industrial starch modified by this treatment shall be used only as internal sizing for paper and paperboard intended for food packaging.
<greek-b>-Diethylaminoethyl chloride hydrochloride, not to exceed 4 pct.	
Dimethylaminoethyl methacrylate, not to exceed 3 pct.	
Dimethylol ethylene urea, not to exceed 0.375 pct.	Industrial starch modified by this treatment shall be used only as internal sizing for paper and paperboard intended for food packaging.
2,3-Epoxypropyltrimethylammonium chloride, not to exceed 5 pct.	
Ethylene oxide, not to exceed 3 pct of reacted ethylene oxide in finished product.	

List of reactants	Limitations
Phosphoric acid, not to exceed 6 pct and urea, not to exceed 20 pct.	Industrial starch modified by this treatment shall be used only as internal sizing for paper and paperboard intended for food packaging and as surface sizing and coating for paper and paperboard that contact food only of Types IV-A, V, VII, VIII, and IX described in table 1 of Sec.176.170(c) of this chapter.
--	------------------------------

(2) A starch irradiated under one of the following conditions to produce free radicals for subsequent graft polymerization with the reactants listed in this paragraph (a)(2)

:

(i) Radiation from a sealed cobalt 60 source, maximum absorbed dose not to exceed 5.0 megarads.

(ii) An electron beam source at a maximum energy of 7 million electron volts of ionizing radiation, maximum absorbed dose not to exceed 5.0 megarads.

Acrylamide and [2-(methacryloyloxy) ethyl]trimethylammonium methyl sulfate, such that the finished industrial starch-modified shall contain:	For use only as a retention aid and dry strength agent employed before the sheet-forming operation in the manufacture of paper and paperboard intended to contact food, and used at a level not to exceed 0.25 pct by weight of the finished dry paper and paperboard fibers.
1. Not more than 60 weight percent vinyl copolymer (of which not more than 32 weight percent is [2- (methacryloyloxy)ethyl] trimethylammonium methyl sulfate).	
2. Not more than 0.20 pct residual acrylamide.	
3. A minimum nitrogen content of 9.0 pct.	

List of reactants	Limitations
--	------------------------------

(b) The following adjuvants may be used as surface-active agents in the processing of industrial starch-modified:

Polyethylene glycol (400) dilaurate.
Polyethylene glycol (400) monolaurate.
Polyoxyethylene (4) lauryl ether.

(c) To insure safe use of the industrial starch-modified, the label of the food additive container shall bear the name of the additive ``industrial starch-modified,'' and in the instance of an industrial starch-modified which is limited with respect to conditions of use, the label of the food additive container shall contain a statement of such limited use.

[42 FR 14609, Mar. 15, 1977, as amended at 42 FR 49453, Sept. 27, 1977]

References

"Gluten Intolerance Fact Sheet." Web page. Available at http://www.kswheat.com/factsheets/wheatallergies.html.

"Glutten Free Foods Ltd." Web page. Available at http://www.glutenfree-foods.co.uk/company.html.

Previsao de safra. 1997. *Informacoes Economicas* 27, no. 4: 85.

VAPZA lanca mandioca pronta. 24 July 1997a. *Gazeta Mercantil*.

Pao de queiuo agora globalizado. 30 October 1997b. *Gazeta Mercantil*.

A receita da vovo. 3 November 1997c. *Gazeta Mercantil*.

A Hungria e apenas o comeco. 19 February 1998a. *Gazeta Mercantil*.

Novidades na industria de alimentos. 12 January 1998b. *Gazeta Mercantil*.

Venda de Sao Geraldo aquece a disputa pelo pao de queijo. 19 January 1998c. *Gazeta Mercantil*.

Ababio, J. T. 1998. "Factors affecting the development and production of foodgrade cassava flour." MPhil thesis, Department of Nutrition and Food Science, University of Ghana, Legon, Ghana.

Abass, A. B., A. O. Onabalu, and M. Bokanga. 1997. Introduction of high quality cassava technology in Nigeria. Presented at *ISTRC meeting in Trinidad*.

Alfa Laval Limited. 1992. *Technical Bulletin: The Alfa Laval manioc starch process*. Sweden: Alfa Laval Limited.

Arita, Toshiyuki. "Anti-Allergic Cereal-Based Noodles." Web page. Available at http://foodnet.fic.ca/research/jstnmr95.html#noodles.

Azevedo, J. H. 1996. Abrir seu Proprio Negocio. *Alimentos congelados.* editor Sebrae, 7-8. Brasilia.

Balagopalan, C., G. Padmaja, S.K. Nanda, and S.N. Moorthy. 1988. Cassava in Food, Feed and Industry. 160-164. Boca Raton, Florida, USA: CRC Press.

Bokanga, M. 1998. Expanding cassava utilisation in Africa. Presented at the *CFC*

Workshop on Local Processing and Vertical Diversification of Cassava in Southern and Eastern Africa.

Bokanga, M., and L. H. O. Djoussou. 1998. Important factors for the utilisation of root and tuber crops in Africa. Presented at the *CFC Workshop on Local Processing and Vertical Diversification of Cassava in Southern and Eastern Africa*.

Canadian Celiac Association. Web page. Available at 190 Britannia Rd. E. Unit #11, Mississauga, Ontario L4Z 1W6 1-800-363-7296.

Canadian Celiac Association. 1998. *Eat Well Be Well: A Guide to Gluten Free Manufacturer's Products*, CCA, Toronto.

Canadian Pulp and Paper Assocation. *Reference Tables*. 1997.

Canadian Pulp and Paper Association. "The Future of Paper." Web page. Available at http://www.open.doors.cppa.ca/english/info/future.htm.

Cereda, M. P., P. M. T. Ospina, L. E. Urbano, and F. Urbano. 1997. *Projeto de elaboracal de mandioca congelada*. Botucatu, SP: Centro de RAizes Tropicais 0 Cerat.

CONAB. 1997. "Indicadores da agropecuaria." Ministerio da Agricultura e do Abastecimento, Companhia Nacional de Abastecimento.

Cooley, Jennifer. 1997. "Celiac Sprue." Web page. Available at find.

Crookson, R. K. 1979. The Story of Waxy Corn Maize Varieties, Uses and History. *Crops and Soils* 32, no. 9: 11-13.

Day, G., A. J. Graffham, J. Ababio, and M. Amoako. 1996. *Market potential for cassava based flours and starches in Ghana*, NRI Report. Natural Resources Institute, Chatham United Kingdom.

Djoussou, L. H. O., and M. Bokanga. 1997. Cassava and wheat consumption in Africa: New opportunities for cassava in the 21st century. *Proceedings of the sixth triennial symposium of the International Society for Tropical Root Crops - Africa branch*Ibadan Nigeria: International Institute of Tropical Agriculture.

Dux, E. F. W. 1967. Production and use of starch adhesives. *Starch Chemistry and Technology.* (eds.) R. L. Whistler, and E. F. Paschall, 538-52. Vol. II. New York, USA: Academic Press.

Fabiano, E. 1998. Cassava in the Malawi economy. Presented at the *CFC Workshop on Local Processing and Vertical Diversification of Cassava in Southern and*

Eastern Africa.

FAO. Draft Working notes on selected chapters of "The World Cassava Economy: Recent trends and medium-term outlook". *Global Cassava Development Strategy: Progress Review Workshop*Rome: International Fund for Agricultural Development.

FAO. 1995. Codex standard for edible cassava flour, CODEX 176-1989 (Rev. 1-1995). *Codex Alimentarius.*, 133-36. Vol. 7.

FAO. 1997. Extracted from "Food Outlook" (March/April 1997) of the Commodity Note on Cassava. *Global Cassava Development Strategy: Progress Review Workshop*Rome: International Fund for Agricultural Development.

FAO. "FAOSTAT Database Collections." Web page, [accessed 1999]. Available at http://apps.fao.org/cgi-bin/nph-db.pl?subset=agriculture.

FAOSTAT. Web page. Available at http://apps.fao.org/.

Faure, J. 1993. *Feasibility study on starch products on non cereal origin in Benin and Ghana*, FAO, Rome.

1995. FAXJOURNAL. 1 to 80. CERAT/UNESP.

Fergason, Virgil. 1994. High Amylose and Waxy Corns. *Specialty Corns.* Arnel R. ed. Hallauer, 72. CRC Press.

Fidel, M. M., H. C. Dolores, E. B. Bauza, and M. S. P. Dionhlay. 1992. Phenol formaldehyde fortified starch adhesive for plywood. *FPDRI Journal* 21: 1-19.

Food Allergy Center. Web page. Available at http://www.magmacom.com/~pwray/altmed/foodallergy.htm.

Fundacao Sistema Estadual de Analise de Dados, SEADE. "Pesquisa de Condiicoes de Vida." Web page. Available at http://www.seade.gov.by.

Glucoset. 1994. *A feasibility study: Production of native and modified cassava starch in Ghana*, Gllucoset Limited, Accra, Ghana.

Government of Canada. "Trade Data Online." Web page. Available at http://strategis.ic.gc.ca/.

Graffham, A. J., J. T. Ababio, N. Dzidezoave, N. Day, G. Andah, A. Budu, G. S. Ayernor, S. Gallat, and A. Westby. 1997. Market potential for cassava flours and starches in Africa: A case study in Ghana. Presented at the *ISTRC meeting in Trinidad*.

Graffham, A. J., and N. T. Dziedzoave. 1998. *Preparation of starch based adhesives and glue extenders from cassava flour in ghana*, Joint Report of the Food Research Institute and Natural Resources Institute, Chatham, United Kingdom.

Henry, G., and V. Gottret. 1996. *Globval Cassava Trend. Reassessing the Crop's Future*, CIAT Working Document No. 157. CIAT, Cali, Colombia.

Henry, Guy, Andrew Westby, and Chris Collinson. 1998. *Global Cassava End-Uses and Markets: Current Situation and Recommendations for Further Study*, European Group on Root, Tuber and Plantain, France.

Hillstrom, Kevin, Editor. "Encyclopedia of American Industries Volume 1: Manufacturing Industries." Web page.

International Starch Institute. Web page. Available at http://home3/inet.tele.dk/starch/isi/stat/usa97.htm.

Jeffcoat, R. 1998. Starch polymenr or particle. Presented at the *AAB meeting on Production and Uses of Starches*.

Kleih, U. 1994. *Feasibility study of cassava production and marketing in Zimbabwe*, NRI Report. Chatham, United Kingdom.

———. 1998. *Business plan for cassava project in Zimbabwe*, NRI Report. Chatham, United Kingdom.

1994. ITCF.

Maneepun, S. 1997. Utilization of Tapioca in Food Industry. *TTTA Annual Yearbood 1996.*, p. 75-82. Bangkok, Thailand.

Mosquera, P. L., and P. M. P. Chacon. 1992. *Evaluacion socio-economic de la produccion y comercializacion de almidon de yuca en algunos municipios en el norte del Departamento del cauca, colombia*, Corporacion Universitaria Autonoma de Occidente, Division de Ciencias Economicas y Sociales, Cali, Colombia.

National Corn Growers Association.

National Restaurant Association. 1989. *The Market for Ethnic Foods: A Consumer Attitude and Behavior Study*.

Natural Resources Institute. 1992. *COSCA Phase 1 Processing component* , COSCA Working Paper No. 7. Natural Resources Institute, Chatham, United Kingdom.

Nivoba Engineering. 1995. *Process description for cassava starch plant with a capacity of 40 tons of commercial cassava starch per 24 hours*, Nivoba Engineering, Veendam, Holland.

Onabalu, A, and M. Bokanga. 1998. The promotion of cassava as a commodity for the food industry: A case study in Nigeria. Presented at the *CFC Workshop on Local Processing and Vertical Diversification of Cassava in Southern and Eastern Africa*.

Ospina, P. B., M. V. Gottret, D. Pachico, and E. L. C Cardosa. 1998. *CIAT's integrated cassava research and development (ICDR) strategy: a case study on adoption and impact in Northeast Brazil*, CIAT working document, Cali, Colombia.

Paperfo. "New Starch Consumption leads Chemical Growth." Web page. Available at http://www.paperfo.com/prodftp/starch.htm.

Paperfo. "Starch Product Applications Pressured by Supply Conditions." Web page. Available at http://www.paperfo.com/prodftp/starch96.htm.

Plucknett, Donald L., Truman P. Phillips, and Robert B. Kagbo. 1998. *A Global Development Strategy for Cassava: Transforming a Traditional Tropical Root Crop: Spuring Rural Industrial Development and Raising Incomes for the Rural Poor*, International Fund for Agricultural Development, Rome.

Sarmento, S. B. S. 1997. *Caracterizacao da fecula de mandioca (Manihot esculenta C.) no periodo de colheita de cultivares de uso industrial*, Universidade de Sao Paulo, Faculdade de Ciencias Farmaceuticas, Sao Paulo.

SIS Engineering (Ghana) Limited. 1996. *Product profile and price list for 1996*, SIS Engineering Limited, Kumasi, Ghana.

Sunderland, Robert. 1997. "The Production of Third Generation Snacks." Web page. Available at http://www.wenger.com/new_cfw1.htm.

The Thai Tapioca Development Institute. 1998. *Information Bulletin*. Bangkok.

Report of Strategy Agricultural Commodity Project: cassava. 1997 Bangkok: Agribusiness Research Unit, Department of Agricultural and Resource Economics, Faculty of Economics, Kasetsart University.

Trim, D. S., and A. Curran. 1993. *Report on a visit to India to undertake a process audit of cassava starch productgion*, NRI Report. Chatham, United Kingdom.

TTTA. 1997. *Thai Tapioca Trade Association Yearbook 1996*, Thai Tapioca Trade Association, Bangkok, Thailand.

———. 1998. *Thai Tapioca Trade Association Yearbook 1997*, Thai Tapioca Trade Association, Bangkok, Thailand.

U.S. Department of Commerce Bureau of the Census. 1997. *Statistical Abstract of the United States 1997*.

USDA-AMS Market News Service. "Terminal Market Prices." Web page. Available at http://gnv.ifas.ufl.edu.

Vilpoux, O., C. L. R. Vegro, M. P. Cereda, and J. R. da Silva. 1995. *Analise dos canais de distribuicao de pao de queijo e biscoito de polvilho, na didade de Sao Paulo*, FAPESP Report, CERAT/UMESP.

Vilpoux, O. 1997. "Coordinations verticales entre entreprises transformatrices de manioc et producteurs agricoles, au sud du Bresil." de l'Institut Polythecnique de Lorraine (INPL).

———. 1998. *As industrias de mandioca nos estados de Santa Catarina, Parana, Sao Paulo, Mato Grosso do Sul e Minal Gerais*, CERAT/UNESP, Universidade Estadual Paulista, Borucatu, Brazil.

Watson, Stanley A. 1988. Corn Marketing, Processing and Utilization. *Corn and Corn Improvement, Third Edition.* Sprague G.F., and J.W. Dudley ed., 886. Madison, Wisconsin: Agronomy.

Working Group on International Agricultural Research. 1997. *The Crucial Role of International Agricultural Research: Improving Global Food Production, benefiting U.S. Agriculture, enhancing the economies of developing countries and stimulating U.S. Trade*, National Center for Food and Agricultural policy, Washington, DC.

Wurzburg, O. B. 1987. *Modified Starches: Properties and Uses*. Boca Raton, Florida: CRC Press Inc.